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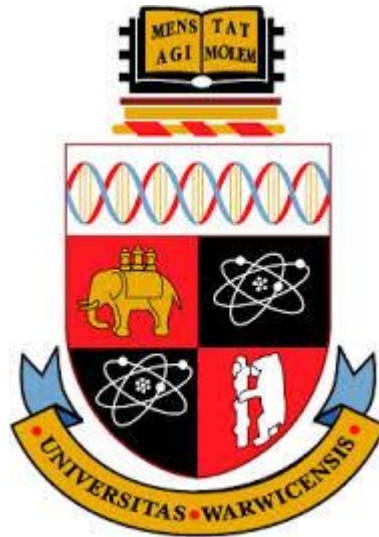
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**A framework to support multilingual mobile learning:
A South African perspective**

By

Mmaki Elisabeth Jantjies

**A thesis submitted in partial fulfilment of the requirements for the
degree of**

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Dedications

I dedicate this research to the following late persons:

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“To live in the hearts we leave behind is not to die”, by Thomas Campbell

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Declarations

This research has been written by myself and presents work that I have done except where otherwise stated. The thesis has not been submitted to any other university for degree purposes. Parts of the thesis were published as follows.

1. Chapter 4 presents a case study of using multilingual mobile learning in formal environments. The paper was published in the conference proceedings as follows:

Jantjies, M. & Joy, M. (2012). Multilingual Mobile Learning-A Case Study of Four South African High Schools. 11th World Conference on Mobile and Contextual Learning. Finland, Helsinki. A detailed paper of the results of chapter 4 has been submitted for review in a journal as follows:

2. Jantjies, M. & Joy, M. (2013). Mobile learning supporting code-switching learners: A South African case study. Journal of Education technology & society.
3. Chapter 5 presents a case study of using multilingual mobile learning in informal environments. This paper was published in the conference proceedings as follows: Jantjies, M. & Joy, M. (2013). Mobile learning through indigenous languages: learning through a constructivist approach. 12th World Conference on Mobile and Contextual Learning. Doha, Qatar.
4. Chapter 8 presents a case study of the framework proposed in this thesis. This paper was published in the conference proceedings as follows: Jantjies, M. and Joy, M. (2014). A framework to support mobile learning in multilingual environments. IADIS 10th International conference on Mobile learning. Madrid, Spain.

5. Chapter 9 presents an evaluation study of the framework proposed in chapter 8. This paper has been submitted for review for the IMCL conference:
Jantjies, M. and Joy, M. (2014). Supporting mobile learning in multilingual high school classrooms: An evaluation study of a proposed framework. The International conference on Interactive Mobile Communication Technologies and Learning, Greece.

Abstract

The proliferation of mobile phone ownership across the world has motivated education technology specialists to find ways of supporting the process of learning in both formal and informal environments through mobile devices. Mobile learning has introduced an opportunity for extending resources to learners in schools through ubiquitous devices. While there have been various pedagogical guidelines on how to create mobile learning systems for learning, little research presents support for developing multilingual mobile learning technology that can be used to support high school learning. This research presents mainly three case studies contributing to the development of a framework that can be used to support the development of multilingual mobile learning software combining technical and key pedagogical considerations to support the software development process. The approaches described by this framework also take into consideration the code-switching practice which is common in multilingual classrooms. Code-switching is a technique used in multilingual classrooms by teachers and learners to support learners to both interpret and understand learning content switching between two human languages in order to gain deeper perspectives on a topic. The first case study presented in the thesis describes creating appropriate content and learning activities that can be used through mobile learning supporting the code-switching behaviour of multilingual learners in formal learning. The second case study reports on supporting learning activities and content in informal learning environments. The third case study reflects on different language support characteristics that can be embedded in systems or used as additional systems to support multilingual mobile learning content development in cases where language specialists are a rare resource. The thesis is completed through an evaluation of the framework's practicality in supporting the pedagogical considerations to be made when developing mobile learning systems for use in multilingual high schools. The cases presented in this thesis are based on a South African context.

Abbreviations

ANA	Annual National Assessments
CText	Centre for Text Technology
CSIR	Council for Scientific and Industrial Research
DOE	Department of Education
DOBE	Department of Basic Education
HTML	Hyper Text Mark-up Language
ICT	Information and Communications Technology
MySQL	My Standard Query Language
PHP	Hypertext Pre-processor
SPSS	Statistical Package for the Social Sciences
SSADM	Structured Systems Analysis and Design Method
Wi-Fi	Wireless Fidelity
WML	Wireless Markup Language
XHTML	Extensible Hypertext Mark-up Language
XML	Extensible Mark-up Language
UNESCO	United Nations Educational, Scientific and Cultural Organisation

Chapter 1

Introduction

This chapter presents the research motivation which inspired the origination of this thesis. The chapter also presents the research questions drawn from the challenges presented in the research motivation. Finally the chapter outlines each chapter of the thesis which formulate the answers to the research question.

1.1 Research motivation

This research was motivated by findings from a previous interpretive study which formed part of my undergraduate research project. In this study I worked with different high schools in the North West province of South Africa to establish the problems that learners experienced in relation to accessing learning resources. My project also considered how mobile learning could have a significant impact in reducing the challenges of accessing educational resources. My role in this project was to interpret the results as I had found them. Through a series of interviews and questionnaires taking place between the researcher, the learners and different teachers, my research revealed that the available learning resources were insufficient to enable a seamless learning environment and so contributed to the poor performance of under-resourced schools. These resources included: an inadequate number of text books or prescribed working books for learners; a lack of access to any form of digital technology both within schools (especially prevalent in rural schools) and at home which contributed to a digital divide between urban (well-resourced) and rural (under-resourced) schools; and the inability of learners in resource-constrained schools to afford to purchase the learning material sold in bookshops. These problems were amongst the greatest contributing factors to the

success or failure of education in South Africa, especially in rural and remote schools (Makgaka, 2008). The research was also motivated by the lack of mobile learning technology that supports learners from multilingual learning environments who use unique methods to learn as a result of their multilingual learning background.

The popularity of mobile devices has reshaped the aspect of how we perceive the importance of mobile technology. A definition of mobile technology is any form of technology which is not restricted to a specific area for it to be optimally used. This can include mobile telephones, laptops, palmtops and various other mobile devices. Today mobile devices are used to support learning. The aim of this support is to enable the dissemination of education reaching people from different learning environments, without binding them to a specific location while learning.

The South African government has established a research center through the National Department of Science and Technology. The center, Council for Scientific and Industrial Research (CSIR) under the Meraka Institute, has also been involved with amongst others various mobile learning research initiatives (Ford and Leinonen, 2009; Botha *et al.*, 2012) . Their research in relation to supporting mobile learning is based on South African higher learning institutions and some primary and secondary schools. Most of their findings (which will be reflected in my literature review) have reflected the need for continuous research into improving educational software to support learner's performance, especially in disadvantaged communities. Currently the South African government through the National Department of Basic Education, with the support of the CSIR has rolled out the use of tablets PCS and free Wi-Fi to support learning in South African public schools. The project has already begun in the Gauteng province. The aim of the project is to enable seamless e-learning throughout government schools (SouthAfricanInfo, 2013).

With the recent developments of introducing access to tablets for learning in schools in South Africa, there is now a much greater need for software which can now support the process of learning, in both formal and informal environment also considering the contextual challenges. In this research project, we will evaluate how mobile learning can be used to support multilingual learners in under-resourced learning environments. In learning environments where students learn in a language which is not their home language, in classrooms managed by multilingual teachers, multiple languages are used to support learners in understanding what they are being taught. This is especially relevant to subjects that require a deep understanding of the Language of Learning and Teaching (LOLT) such as for mathematics and science (Jegede, 2012) . In South African schools in particular, learners are taught in more than one language to compensate for their difficulties in effectively comprehending the LOLT (Mbali and Douglas, 2012) .

Education technology developers often struggle to achieve a pedagogically sound development approach to support the process of learning in formal and informal environments (McCombs, 2000). This research provides a pedagogical development framework which considers the South African multilingual and mobile learning context providing developers with a pedagogy consideration approach that focuses on developing multilingual content while supporting formal and informal learning. In developing the framework we follow a theory development process where learning practices drive the use of technology, as opposed to technology defining how learning should occur.

For the understanding of this research the word “learners” will refer to primary or secondary school learners. The word “student” refers to higher learning institution learners. This distinction is also officially used by the South African government when differentiating the two in the different official education related communique.

In conclusion the possibility of technology access through education opens an opportunity for educational improvement, with the available mobile learning technology, contextualised mobile learning is able to support learning in multilingual environments.

1.2 Research questions and objectives

In this section we evaluated the research questions which were drawn from the research motivations. Research objectives are then drawn for the main questions.

Question 1: How can mobile learning be used to support multilingual learners in their formal learning process?

Question 2: How can mobile learning be used to support multilingual learners in their informal learning process?

Research objectives:

- Establish how learning occurs in formal and informal environments and how learning resources are currently used to support this process;
- Identify the support that mobile devices can have through tailored software development in supporting learning content and activities by providing pedagogy approaches to the development process;
- Identify the process of code-switching and how learning content and activities supported through mobile learning can be tailored to support the process of code-switching for learners.

This first main questions and set of objectives identify the role that mobile devices can play in supporting current teaching and learning practices in multilingual formal and informal learning. The questions establish: *how learning occurs and the role that mobile devices can play in improving the process of learning in multilingual*

environment; what are the system development processes that can be followed to create a mobile learning system to be used in high schools to support learners; how can content be developed and presented through mobile devices to support formal and informal multilingual learners who code-switch while learning?

In chapter 4 and 5 we investigated the process of teaching and learning in formal and informal multilingual high school environments. After establishing teaching and learning objectives in both formal and informal contexts, we further established how mobile learning systems can be developed to support the learning objective. We also investigated how to create learning content which supports the code-switching process through a mobile learning system named M-Thuto by presenting the content using various methods. In chapter 6 we investigated the process of supporting multilingual content development through approaches such as language content support, embedding translation within a system and external machine translation when developing mobile learning systems in environments where human translators are scarce. Data were collected in chapter 4 and 5 to evaluate the pedagogical characteristics of the M-Thuto system that should be considered when designing similar mobile learning systems. We also considered machine translation approaches in providing relevant support in this context through chapter 6.

Question 3: How can a mobile learning framework be used to develop mobile learning systems that support the learning process in multilingual learning environments?

Research objectives:

- Identify and present support for pedagogical approaches which teachers use to provide learning in both formal and informal multilingual environments through mobile learning;

- Identify and present support for the process of code-switching for multilingual learners in formal and informal environments.

The third research question evaluates the different pedagogical considerations to be made when developing a mobile learning system to be used in formal and informal multilingual learning. In chapter 7 we evaluate existing mobile learning frameworks and their shortcomings. In chapter 8 we use a framework based on previous case studies presented in chapter 4, 5, 6 and 7 to present: The role players in a high school mobile learning eco-system and how they enable a mobile learning process to occur, adapting traditional system development approaches to create mobile learning systems, supporting the teaching and learning objectives with traditional learning theories to create multilingual mobile learning content to support different learning activities. The framework finally presents how pedagogy can be developed and presented to consider the code-switching nature of high school learning. Chapters 9 evaluates the framework using interviews conducted with teachers and students providing a perspective on the framework's ability to provide appropriate pedagogical support for learning in both formal and informal multilingual environments. The evaluation also provides an improvement of the approaches based on the findings of the assessment.

1.2 Chapter division

The research chapters in this thesis present the following findings

Chapter 2

In chapter 2 we begin by reflecting on how the research in this thesis was conducted. Chapter 2 details the research methodology which we followed to establish the answers to the main research questions.

Chapter 3

In chapter 3 we evaluate past and current developments in the mobile learning environment. We also evaluate the different mobile learning initiatives and their contributions to supporting the development of contextualised mobile learning systems.

Chapter 4

In chapter 4 we present the M-Thuto system. M-Thuto is a mobile learning system which was developed to support the learning process in multilingual formal environments. This support is provided by giving learners access to class notes, class quizzes and class exercises through two languages, namely English and Setswana, through a dedicated learning system. The chapter provides a case study of how the system was developed and an evaluation of the interaction process between learners and the system. The results of chapter 4 are later used to create a framework in chapter 8 based on how the M-Thuto system was developed and how it was used to support learning, describing approaches that can be used to develop similar systems providing multilingual mobile learning support.

Chapter 5

Chapter 5 presents the second phase of the M-Thuto system. In the second phase we establish the ability of mobile learning to support multilingual learning in informal environments. The chapter then describes how the learners interacted with the system by creating learning audio clips and uploading them onto the system in an informal environment. The chapter thus presents how mobile learning can be used to support informal learning. The chapter also presents the results from the interaction process between learners and the system. The results of the study contribute to the framework in chapter 8 describing pedagogy approaches on how

mobile learning systems can be developed to support informal multilingual mobile learning.

Chapter 6

In chapter six we explore other methods that can be used to support multilingual mobile learning content development. These processes are presented through a secondary case study. We begin by describing the language content support technique and machine translation as approaches that can be used to support content development in more than one language. These are especially helpful where language specialists may not be frequently present to support the multilingual content development process. These techniques have been used in the multilingual mobile learning framework proposed in chapter 8 to support developers on how to embed multilingual language support in learning content.

Chapter 7

In creating a mobile learning framework, chapter 7 describes the process that we used to create the theories that support the multilingual mobile learning framework and described how we arrived at the framework.

Chapter 8

Chapter 8 presents a proposed multilingual mobile learning framework that can be used to assist non-educational specialists to create multilingual mobile learning systems. The framework presents the pedagogical layer of a systems development approach. It presents the role players of multilingual mobile learning systems in formal and informal learning, issues to consider when developing systems to support mobile learning and presents development guidelines for multilingual mobile learning content and activity support to be used in formal and informal learning.

Chapter 9

In chapter 9 we evaluate the framework from the perspective of the teachers and the students. The teachers provide an evaluation as the experts who teach in multilingual environments. The students provide the users perspectives of systems created using the framework. The valuation establishes if the principles proposed by the framework provide appropriate pedagogical development support.

Chapter 10

Chapter 10 concludes the research, revisiting the research questions and the research contribution while reflecting on the research limitations. The chapter also reflects on future developments related to multilingual mobile learning.

1.3 Project novelty and scenario of the system

There have been several projects in South Africa and throughout the world that introduced the concept of mobile learning in schools with their own objectives. While these research initiatives provided support for mobile learning systems development, not many of them focused on learning in a multilingual environment. There is a need for mobile learning research which concentrates on the challenges of learning using more than one language in both formal and informal learning. There has also been numerous system development approaches through frameworks which reflect on the development approaches of mobile learning systems. These frameworks however do not reflect the classroom learning conditions and how developing systems to be used for learning in high schools is affected by different role players. There is thus a need for development support or guidelines which focus on the pedagogical design perspectives for high school mobile learning support systems as most research has been concentrating on developing mobile learning systems mostly in higher education environments.

The thesis novelty is the contribution it makes by providing system development approaches which can be used to develop mobile learning systems for multilingual high school learning through a framework. The framework presents approaches which focus on the language support and pedagogical support. The process of code-switching in a multilingual environment is a unique approach to learning often found in multilingual schools. The novelty of the framework is to support existing mobile learning pedagogical development considerations by embedding the language switch process in the learning support. The framework further provides approaches for 1. Adapting traditional system development approaches to develop mobile learning systems. 2. Using teaching and learning objectives supported by traditional learning theories to create learning content for mobile learning activities. While mobile learning developers often have the skill to program systems, they often lack the understanding of the pedagogical considerations to be made when developing systems for high school learning. Through case studies, the thesis is able to contribute a framework that can support system developers using these perspectives.

The following scenario provides an example of the learning environment which mobile learning systems developed from the proposed framework can be used to support.

Scenario: A learner in a rural village or urban area has access to a mobile phone at home and a mobile device (i.e. tablet PC) at school. The learner often uses one or more languages to read and interpret learning content. If the learner does not understand the learning content presented in their books written in English, they will refer to their home language and translate or reframe the content so as to understand what they are being taught. The learner uses the same method to ask their teacher related questions.

While the learner does not have access to a computer or any other digital learning resource, the learner has access to a mobile device but does not know how to access different learning resources. A mobile learning system which is accessible on their mobile device is able to provide this learner with a central resource point providing different learning resources which also support their code-switching language behaviour.

Introducing mobile learning systems to the scenario: The learner is provided with a link to a central mobile learning resource which they access through their mobile device. The learner is then prompted to enter their login details. A learner profile appears which gives them access to different learning options and their own learning material. After logging in, the learner will choose a task to attempt: *Read content from the notes prepared by their teacher; attempt a class exercise which after every attempt provides other possible solutions; or access a page which gives a link to other learning resources such as audio notes listing them under a subject or topic area aligned to the learner's curriculum of learning.* Each page of content is available in all South African languages and the learner can press a button at any time in the session to switch to the language view of their choice. The choice of which task they wish to do will be based on their progress at school on the subject they want to learn and what they wish to achieve from their learning also based on their context of learning. For example if they feel that they are not ready to answer complex questions then the learner can read content related to a topic to gain more knowledge. The system allows learners to upload various audio recordings of their previous lessons understanding.

1.4 The research challenges

Conducting research which is based in high schools is often a challenge. There are many regulations which govern research in these environments. As this research began when the South African government had not yet provided support through hardware for mobile learning mentioned in section 1.1, learners had to be provided with mobile phones which gave them full access to the Internet for this study. This was to ensure that every participant had access to a mobile device even though some learners owned mobile phones. This also meant that the cost of the network use had to be carried by the researcher.

It was also a challenge to get access to different schools which limited the number of times that we could conduct research working with learners. This made it difficult to conduct continuous case studies in school environments as the Department of Education has to ensure that lessons are not disturbed, disadvantaging the teachers and learners from obtaining their teaching and learning objectives. This also meant that we could not conduct studies spanning over long periods that would enable us to assess results based on long intervals and monitor progress of using learning systems against the learner's performances before the use of the systems.

The learner's use of the mobile devices, and the websites they could visit, were also regulated so as to ensure that learners were only using the devices for learning purposes. Furthermore most teachers who participated in the study did not have any computing skills and thus while they provide firm pedagogy input, any software to be used in their classrooms had to be pre-developed without expecting teachers to provide technical input.

1.5 Summary

This chapter has presented the research motivation, the research questions and how each chapter maps out to answer the research questions. The chapter further presented the research novelty and the challenges experienced during the research process. The next chapter presents the research methodology and the approaches used to answer the questions presented in chapter 1.

Chapter 2

Research methodology

This chapter provides the methodologies for approaching both the theory and technology development of this research. The chapter describes the method used to reach the underlying research theory of the multilingual mobile learning framework. The chapter also presents the method used for the overarching research process and the method behind the systems design processes including the method of development and implementation. The chapter further presents the methods used for the collection and analysis of different data sets throughout the research.

2. Methodologies used in this research

This research is an interdisciplinary research which combines pedagogical theories with theories drawn from the computer sciences. A mixed method approach has thus been chosen for the research process. Arguments and conclusions drawn from a combination of methodologies provide, according to Creswell and Clark (2011:12), “strengths that offset the weaknesses of both quantitative and qualitative research”. Figure 2.1 presents the different methods used to conduct this research.

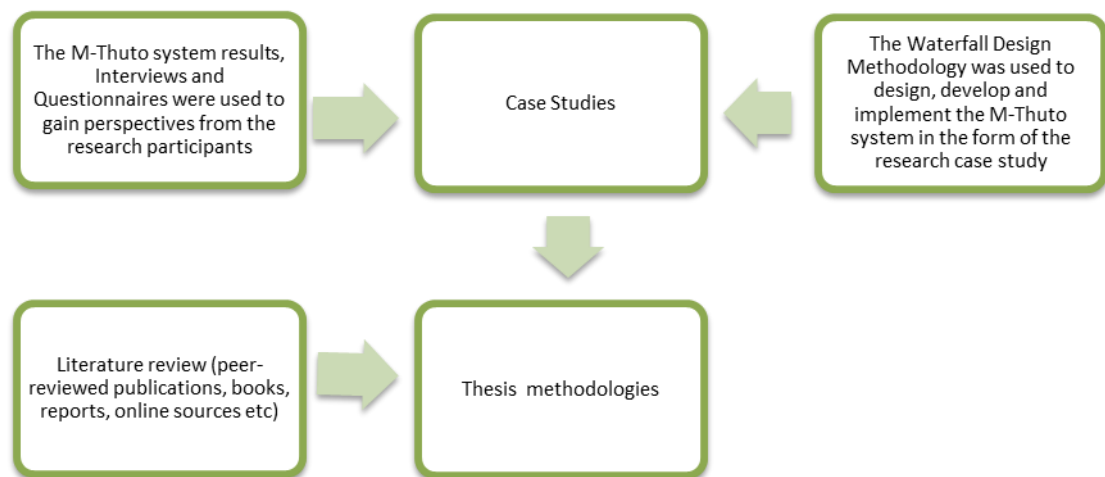


Figure 2. 1 Research methodologies

The research methodology of this thesis is approached through the mixed methodology. The thesis begins with a literature review of the main research area. Case studies are subsequently used to collect both the qualitative and quantitative data used to form the research argument. The research implores the use of interviews and questionnaires to gather data in the case studies as part of the mixed method approach in forming the research argument. Subsequently findings from the case study substantiated by findings from literature are used to correlate an argument of the framework contributed to by this research. An evaluation study of the framework is further presented through a qualitative study with information gathered through interviews. The results of the evaluation provide us with a view on how the framework could further be enhanced based on the views of participants involved in the framework evaluation stage. This chapter thus presents the final outlook of the framework considering the evaluation results.

The following sections explain each approach of the mixed method used within the research.

Figure 2.1 illustrates the different approaches used in this research process. The study begins with a literature review presented in Chapter 3. The literature provides the research background with reference to the past and present state of the research area of mobile learning. Different sources which include amongst others journal publications and books are used to support the review process.

Bryman (2012) describes empirical research as an important factor in creating knowledge as the data collected through empirical research is continuously tested before a theory can be formed. In seeking to answer the research questions posed in section 1.2, case studies explained in greater detail in section 2.1 were conducted. In chapters 4 and 5, we present the design of a mobile learning system called M-Thuto and its use through case studies whereby participants were given an opportunity to support their learning process through the system. The system was designed using an adapted version of a traditional waterfall systems development process described in detail in section 2.4. We selected and adapted the model using it as an approach for the system design process as the methodology emphasises the importance of creating procedural documentation on the processes of development which can be built upon by further users of the framework proposed in this thesis.

It is also important to bear in mind Cohen *et al's.* (2011) suggestion that theory generated from empirical work must be substantiated in terms of existing practice. To satisfy the findings of the research we supported the findings of the empirical studies with literature in chapter 7. In relation to existing theories of bilingual technology, a secondary case study was also analysed from the North West University Centre for Text Technology (CTexT) focusing on their work on supporting bilingual users through content language support and machine translation. This analysis is central to Chapter 6 of this thesis.

The results of both the empirical work and secondary data were used to develop the multilingual mobile learning framework discussed in Chapter 8. Chapter 8 of the framework combines the research findings presented in Chapters 4 and 5 substantiated with Chapter 6 and theory of chapter 7 to suggest paths for creating and enabling a multilingual mobile learning environment through mobile learning systems. In Chapter 9 the suggested framework is validated through an interview-based study.

The data gathered in Chapters 4, 5 and 9 were drawn through surveys explained in detail in section 2.2. Hypotheses emerged in each chapter (notably Chapters 4 and 5) and these hypotheses were further tested using different statistical techniques. The data presented in Chapters 4, 5, and 9 are analysed and discussed using different theoretical themes. In each of these chapters, a discussion of existing research and academic literature serves a means of either substantiating or disputing the findings that have emerged from the results of the case studies.

2.1 Primary and secondary case studies

This research relied upon case studies to collect both empirical and secondary findings. While researchers (Cohen *et al.*, 2011; Somekh and Lewin, 2005) describe case studies as a difficult method to define, Somekh and Lewin (2005) promote case studies as an effective process of using different procedures and theories to correlate an argument. Furthermore, Cohen *et al.* (2011) describe a case study as a relevant activity of researching data that occurs within a specific context. In this research context, different methods were used to achieve a framework which focuses on learners who code-switch in South African high schools. Cohen *et al.* (2011) suggest that case studies require multiple ways of collecting data before a theory is formed.

In the first two primary case studies conducted in this research, teachers were interviewed to contribute to the development of the M-Thuto system providing the system objectives and how it would support the process of both formal and informal learning. Through interviews and questionnaires learners also provided responses on how they used the systems and their perspectives on the support it provided in formal and informal learning. In chapter 6 after a discussion process with members of the Centre for Text technology at the University of North West in South Africa, we present a secondary case study where we evaluate existing machine translation systems and evaluate their contribution towards supporting the development of multilingual mobile learning systems. The CText systems were chosen based on their achievements in enabling South African content which was only predominantly available in English to be obtainable in South African languages through an automated translation system process. Lessons learnt from these systems have contributed towards the development of the framework describing the approaches that can be used in supporting multilingual content presentation in mobile learning systems through chapter 8.

Somekh and Lewin (2005) describe the challenge of case studies as taking a decision on whether the findings are adequate to form a theory or case. In chapter 9 we then evaluate the proposals of the framework which was developed through results of empirical and secondary support. Validating the framework enabled us to establish if the framework was effective in supporting the pedagogical development of mobile learning systems to be used in similar contexts as those presented in the primary case studies in chapter 4 and 5.

2.2 Data collection strategies and analysis process

Surveys are a method of collecting data from research respondents. Surveys can be described categorically as simple, descriptive, cross-sectional, and longitudinal.

Simple describes the use of a small survey that evaluates sample findings occurring in a single instance at one particular time. Cross-sectional surveys describe evaluated findings of a sample of more than one group of participants, also in one instance at a particular point in time. Longitudinal surveys are surveys performed over various instances on the same group of participants (Mertens, 1998) . In this research we used simple descriptive survey methods as this research was only conducted on one particular group of learners in one instance at a time. However, different data collection strategies were used to gather data.

For the purposes of this study, data were gathered both through surveys and as already mentioned through a software program called M-Thuto, while the secondary data were gathered through publications obtained online and from the CText, through reports and publications.

The two main classifications of research strategies used in this research are qualitative and quantitative strategies. A quantitative strategy is the use of arithmetical methods to examine a hypothesis. Questionnaires are some of the approaches that can be used for obtaining quantitative data in a prearranged format from participants (Jingde *et al.*, 2007). There are three types of questionnaire structures that can be used when composing a questionnaire: structured, semi-structured and unstructured. The choice of structure is largely influenced by the scope of the sample size. The larger the sample size the more structured the questions become (Cohen *et al.*, 2011).

As the research sample size was fairly small in all data collection activities in chapter 4, 5, and 9, we used semi-structured questionnaires as part of the survey process to collect data in chapter 4 and 5 which helped to obtain more responses from the participating learners and teachers.

The following benefits are associated with using questionnaires to collect data. Firstly, questionnaires give respondents the opportunity to air their views freely without fearing judgement as they are unmonitored in how they respond. Secondly, questionnaires can reach a large number of respondents so increasing the response rate. The disadvantage of questionnaires is that jargon and the misinterpretation of questions or concepts can lead to irrelevant answers. To mitigate this problem, I was present during the questionnaire response session to give the learners an opportunity to ask questions related to the questionnaires. Questionnaires are also very helpful in research that involves a larger sample of respondents because their use is inherently affordable in financial terms. Moreover, for this research the questionnaires were distributed physically to ensure that I retained contact with the respondents and secured an increased response rate. This contact also provided other opportunities for the respondents to ask any questions related to the questionnaires (Mertens, 1999).

Qualitative data collection is the collection of data through methods such as interviewing (Poggenpoel *et al.*, 2001). For this research we chose a semi-structured approach to interviews with participating learners and teachers in chapter 4, 5 and 9. The advantage of using semi-structure interviews was that they provide a flexible interview process, enabling interaction with the interviewees while allowing the researcher to collect rich data also maintaining a semi-formal interview guide. Unlike in formal interviews which reduce the flexibility of the responses and also transform the interview into a formal environment in which participants may feel that they are being pressured for answers, semi-structured interviews provide a relaxed environment for participants (Staron, 2007).

The above mentioned data collection strategies were thus chosen based on the size of the sample as it was fairly small, the cost of gathering the data as there was a

limited budget for the research and the nature of the data needed to be gathered as both qualitative and quantitative data was needed.

Credible sources such as the IEEE Xplore online library amongst many other online journal portals were used to obtain peer reviewed journals articles. Information was also collected through books, online reports from internationally recognised bodies such as UNESCO. Academic databases such as the EBSCO database were used to review peer-reviewed journal articles and conference proceedings.

The data analysis strategy that has been chosen for this research follows a thematic analysis approach. Initially the primary data collected from interviews and questionnaires were coded. Coding occurs when data is divided and grouped into manageable sizes. Each code has a description which is familiar to the researcher. From these codes, themes are derived which emerge from the various codes. The data is then reported using contextual illustrations grouped under each theme. Unlike other data analysis strategies, thematic analysis focuses on the grouped content of participants' responses rather than concentrating on the manner in which participants' responded (Bryman, 2012).

2.3 Ethics

Research that involves the participation of human beings must abide with guidelines on ethical practice. In order to conduct the studies presented in this research an ethics application was submitted and granted by the relevant institutions (The South African provincial Department of Education and The University of Warwick Biomedical & Scientific Research Ethics Committee reference (REGO-2013-039)). In studies involving the participating learners an application was submitted to the South African provincial government. The South African provincial departments of education provide ethical processes which need to be followed when conducting research within schools. A thorough ethical

consent process is followed, supported by the required application details. In both ethical applications in this study, details were provided on the research process and objectives, participant's security and confidentiality, an insurance of data security, furthermore providing evidence that none of the research activities and processes could bring any harm to participants.

Both institutions and participants were made aware of:

- (i) The clear length, aim and process of the research;
- (ii) Any risk that could be identified within the research process;
- (iii) An assurance that the research aims to protect the confidentiality and anonymity of the participant;
- (v) A guarantee that the participants would participate freely in the research process and so has the right to stop their participation;
- (vi) The assurance that the participants will be notified of the research results (BSREC, 2013; Mertens, 1999).

All participants provided voluntary participation in both the pilot and the main studies with each participant being provided with the above information. As mobile learning was not officially used in the participating schools in chapter 4 and 5 mobile phones were generally banned from schools in South Africa, the principles of the participating schools allowed the use of mobile phones for the purpose of this research.

2.4 The M-Thuto software development process

While this thesis does not concentrate on the technical aspects of systems development, we used an existing software development approach to assist us in designing the M-Thuto system as it was important in providing support for the design and development process.

Software development methods are frameworks that utilise guidelines with the intention of achieving a product at the end of the development process describing design, development and system implementation guides (Ramsin and Paige, 2008). Conventional development methods have been criticised for their lack of user involvement and lack of flexibility during the systems development process as they require a stringent sequence of development (Nerur *et al.*, 2005). On the one hand, these methods are often considered to be well structured in their approach, providing clear pathways to the system development process. Contrary to this, agile and modern methods have also been seen as disorganized and cannot display a clear procedural process of development. However these methods often provide higher user involvement while maintaining product perfection through continuous iterations (Vinekar *et al.*, 2006). Despite the differences in system development approaches, each method is valuable in its own approach. Combining old and new methods can thus be essential in compensating for each method's weaknesses. Both conventional and modern methods can also be tailored to meet the desired objective of the project (Fielden, 2001) .

We evaluated some of the existing methods of systems development assessing their methodology, advantages and disadvantages before choosing a relevant method for this research. The waterfall method is one of the oldest conventional software development methods. It follows a strict sequential approach which involves gathering user requirements, designing the system, coding, testing, implementation and validating the system. The waterfall method is commonly used

for designing products which will not require consistent change to the system. The guidelines for development described by the waterfall model are often well planned and well documented providing a clear approach for other developers to either build upon or maintain the system. The method however does not provide for a high user involvement and can be ineffective where the system to be developed constantly requires input of its users (Beynon-Davies, 1998).

The Structured Systems Analysis and Design Method (SSADM) is another conventional method which similarly follows the waterfall model approach. The method also provides clear processes on developing and maintaining systems. The SSADM requires an initial feasibility study to be performed before any system development occurs. The requirements of the system are then analysed focusing on the needs of the current context where the system will be used. Various system options are then explored to determine the appropriate approach. The next process within the method will then be to specify the requirements providing the specification of the system and the technical development approach. Finally the system will then be developed. One of the shortcomings of the approach is that stages of the model succeed each other while one phase cannot be started without completing the previous stage. There is also a high requirement of documentation of the development process making it an expensive approach to follow especially in large projects (Fitzgerald *et al.*, 2002).

The spiral model is an alternative agile iterative approach of development. This approach of development follows an iterative approach where small prototypes are developed and later plugged into a system mapping them against user requirements. It provides an approach where the system can be designed by different developers and later collaborated to form the main system. The approach is useful in projects that require large amounts of coding while the system development process is continuous and does not have a definitive deadline. The

approach is also useful is supporting collaborative development. Contrary to the previous conventional method, the spiral methodology does not present clear documentation that can be used by other developers. The method is also reactive as oppose to a proactive approach of development where small prototypes contribute to a larger design which continually needs to be built upon or improved. This makes it difficult to plan as completion times depend on different developers of the system (Davis *et al.*, 1988; Nilsson and Wilson, 2012).

The Rapid Application Development (RAD) method is a modern agile methodology which follows a 'trail development approach'. The development of the system involves a high amount of user involvement. Different prototypes of the system are developed and tested through an iterative process before a final product is achieved. The method does not however provide clear planning approaches as the development occurs through a responsive approach. This method is often used in low budget product development as it requires fewer resources for small iterations of the prototype. The method is also best used for development of system which require consistent change to the design of the system (Beynon-Davies, 1998).

Despite the criticism levelled against conventional methods I decided to use the basic software development process of the conventional Waterfall Model as it was the most appropriate model while adapting it with the modern Rapid Application Development (RAD) approach of high user involvement.

As the M-Thuto system is an education system and is aligned with the curriculum system structure, the system structure will thus not continuously change. The system content is also dependent on structure which follows a predetermined curriculum. The waterfall model provides great support for consistency, clear documentation approaches and clear planning which is needed for a system developed for a research study as it requires timelines on what should be achieved by a specific time.

The model follows six basic processes of development: Gathering requirements, designing the model, implementing the model, testing, deploying the model and subsequently maintaining the model (Humphreys, 2009). To overcome the challenges of using the waterfall model, this thesis pursued the following structure for the M-Thuto prototype development process introducing additional steps to the process with the aim of increasing the user involvement and context awareness: gathering requirements, analysing the requirements, designing and developing the system, testing and implementation. Unlike the conventional waterfall model we engaged the users of the system in all levels of the lifecycle. The following sections provide the implementation methods which were applied in chapter 4 and 5 using the waterfall model to develop the M-Thuto systems.

2.4.1 Gathering requirements

Stakeholders play the most important role in the system design process. In this research, the stakeholders are the learners and the teachers. In agreement with this, Roschelle (2003) named the three main components in developing mobile learning technology as the learner, the teacher and the learning platform. These are the main contributors enabling the learning process to occur. Having established the role players, we needed to establish the way in which the technology would be used to support the stakeholders in the learning process. Shih and Mills (2007) propose a model of developing learning technology that is rooted in mobile learning designs. Here, pedagogical perspectives establish the following important considerations which should be made before development: the possibility of variation in the individual learner's way of interpreting educational tasks; the manner in which the application affects the learner's social activities and formal learning settings; the possibility of variation of the mobile device to be used in the learning process; and finally the possibilities of implementing enhanced learning processes in the future. Each role player influences the developmental requirements of the learning tool.

With greater detail we examine below the role of the stakeholders in the multilingual mobile learning system. The system requirements are then documented so that they are used to develop a system based on the users' requirements.

Learners

In developing pedagogy we needed to understand how children learn and learning theories play a vital role in supporting the human computer interaction aspects of the learning tool. Various researchers have identified and defined learning theories based on their findings. Amongst the various classifications of these learning theories, behaviourism and constructivism were prevalent (Ang *et al.*, 2008; Boghossain, 2006; Hunter and Benson, 2007; Nagowah and Nagowah, 2009; Shih and Mills, 2007). Principles of both theories which we explore in greater detail in section 3.12 of this thesis were used to support the development of the M-Thuto system, while chapter 4 and 5 details how the principles were used to support different learning activities.

Educators

Technology use is often popular amongst the younger generation. Learners often invest much more time and energy into it, making them more fluent with the latest developments in comparison with adults. An interesting challenge arises where educators are compelled to facilitate learners who possess much greater skills than they personally have acquired. Such a situation is prevalent for many educators in the 21st century. As Peters (2007) highlights, technology-inclined learners have become a challenge during lessons because they require a style of education that builds upon their existing knowledge rather than simply accept what they are being taught. In such a context, teachers may become weary of using technology in their classrooms.

More positively, Rogers and Price (2008) highlight that the introduction of mobile learning also introduces new educational paradigms for teachers. It can stimulate

teachers to become more progressive in implementing modern educational techniques when they are forced to allow learners to use their mobile devices to explore other methods of learning effectively. Educators are also faced with various challenges when having to implement mobile learning in their classrooms. These include the awareness that mobile phones can become a disruption to learners and that learners also face difficulties in undertaking the collaborative work through a mobile device. These were the challenges that were considered before embarking upon the research. The challenges were mitigated by constantly involving the teacher in the development process. When developing the content structure of each version of the M-Thuto application, the following question became of key importance: *Were we to develop an authoring tool or an application where we would have to design and update the learning content?* The research context in which the case studies were conducted both challenged and contributed to the decision.

Firstly, none of the participating teachers had any form of intense computing background. Secondly, there was a limit on resources and teachers needed to have their own computers to update the learning content. Considering that the research period would be conducted over a month, it would be difficult to teach the teachers how to use an authoring tool in such a small timeframe. Therefore, it was decided to develop an application that we could control through their pedagogy support and update. As I was in constant communication with the teachers this was not a concern, but it would have been a challenge for a longer period of study. With a longitudinal study, the teachers can be trained to use an authoring tool or a system allowing content management support features giving them greater control to be able to update their own content.

At the beginning of the system design and development process, we initially engaged with the teachers and principals by firstly explaining mobile learning to them, then explaining the research objectives and assuring them that this work is a

contribution to research and did not necessarily focus on the teachers' understanding of technology. We also agreed on the boundaries to be set on mobile phone use in the classes under observation. Before the research process began I also liaised with the teachers on the development stage of the application developing the content based on their contributions described in detail in section 4.4 and 5.4. We discussed and agreed upon the structure of the application used in Chapter's 4 and 5 with participating teachers and the North West head of mathematics department.

The teachers and learners thus set the systems requirements based on what was to be learned, why would it be learned and how would it be learned.

2.4.2 Analysis of user requirements - contextual resources and challenges

The user-requirements in this research refer to the learner's needs of a multilingual mobile learning system which are presented in the research motivation in section 1.1. The learners needed a mobile learning system which would support their multilingual learning activities in both formal and informal environments, while the teachers needed a tool to support their learners. The contextual resources in this case were the devices that learners mostly had access to which were mobile phones. This meant that the development process of the system would mainly be customised for different types of mobile phones. The contextual challenges as already mentioned were: some learners not having access to mobile phones – all learners were provided with uniform mobile phones and Internet access; teachers had no skill of computer use – teachers were involved in all stages of the system and thus knew how and when they would use the system allowing them to plan their teaching supporting it with the system.

2.4.3 System design and development

The software interaction process was based on a client - server structure. The software used to develop the system was open source technology as it is free to use and enables high user flexibility. It also gives one the full opportunity to control the software development process when writing the code of software. In general, open source practice creates space for creativity and opportunities for various ideas to be built into the technology (Ralston, 2009).

The systems development process began by examining different software development languages before deciding on the appropriate language for the development process. HTML is the standard Hyper Text Markup language for website design. When coming to mobile device applications a new language has become necessary to enable websites that cater specifically for miniature mobile screens. The Wireless Markup Language (WML) evolved as the most appropriate language to cater for mobile websites. Unfortunately, the webpages developed from this language were too simple and unattractive for users (Lee, 2001). Extensible Markup Language (XML) later emerged as the rules or guidelines that govern the development of webpage's for wireless or portable devices. Every webpage developed for portable devices then had to be designed through XML (Sanborn and Lattig, 2000). This led to the improved language of the HTML through the introduction of the Extensible Hypertext Markup Language (XHTML), which emerged as the best means of reducing the gap between HTML and WML to develop web content (Lee, 2001). XHTML was thus chosen as the most appropriate principal web development language for the software design process in this thesis. Data used in the system was stored on a database. The interaction between the software application and the database was facilitated through PHP. PHP is known as a hypertext preprocessor. It is a scripting language that ensures the connection between a database and a website. It contains wording or coding

similar to the C and Pearl language (Yager, 2001). In this system we operated PHP through Apache as its web server. The database where the data was stored was then developed through the use of the open source database language, MySQL (Rupley *et al.*, 2005).

In the database, each user had a profile with a username and a password. The metadata in the data warehouse consisted of a learner's passwords and their learning content, also preserving the quiz results and the pattern of using bilingual learning content described in Chapter 4. Finally, the learners' bilingual voice clips, described in chapter 5, were also stored in the data warehouse. The teacher was also able to access the system through their profile to gain access to the learner's results and was able to monitor performance of learners as will be noted in chapter 5.

2.4.4 Testing and implementation

The M-Thuto application was first piloted in both chapter 4 and 5 amongst children who responded to voluntary participation requests sent to the schools in which we were granted access to conduct research as reflected in section 2.3. In this thesis we regarded the testing stage as the pilot study process amongst voluntary participants before use by other participants in chapters 4 and 5. The participants in the pilot and the main studies were aged between the ages of 16 and 18 years and were in their final grades of high school (between grades 10-12). The learners volunteered to participate in the pilot using their own mobile phones in the study. The perspective of the pilot focusing on the technology was to establish: any usability concerns that included the user-interface presentation; the ability of the system to handle several users accessing the system through different mobile phones; the ability of the system to handle requests from learners in terms of switching between pages to view content in different languages and the ability of the system to seamlessly interact with the database to retrieve the learners requests;

Based on the responses of the learners, the system was improved to provide an enhanced version for the main research project implementation stage.

In this thesis we regard the implementation stage as the use of the system amongst learner participants after the pilot stages. The implementation of the system is presented in Chapter's 4 and 5 of this study, which describe how learners interacted with the system and gave feedback on their interaction process. The M-Thuto application required a mobile connection to the Internet before the learners could access the system. The learning environment in which both versions of M-Thuto were used considered both mobile and site-based learning. The delivery of the application was enabled by an Internet mode of transmission so as to allow learners to access up-to-date content from any location. Chapter 4 and 5 reflects on both testing and implementation stages of the M-Thuto system.

2.5 Ensuring research quality

Triangulation is the use of more than one research method of gathering information for a particular research to ensure research quality. The data gathered using this method presents different paths of collected data to form one argument. This reflects that the data has been scrutinised using many methods to support a research case (Cohen *et al.*, 2011). In this research, interviews, questionnaires and case studies were used in combination to gain a more reliable and valid data.

To guarantee that the results yielded from the data collection process are of the desired quality it was important to ensure that data are *reliable, generalizable and valid*: *Reliable* data can be generated from the use of stable methods for the data collection process. In this study, the data collection method was consistent with each experiment that was conducted. Interviews and questionnaires which examined similar objectives were used to collect data. This ensured some form of reliability of the data as the process of gathering the data could not guarantee

absolute reliability since the questions of the experiments would at times differ with the context and objective of each study. This was due to the fact that the studies evaluated formal and informal learning mobile learning processes. *Generalizable* data is defined as when the findings can be applicable to other similar settings when the same research approach is used. While the research outputs can be used to gain an outlook of how mobile learning can be supported in similar multilingual environments, elements involving human and social interaction aspects of the research cannot be guaranteed to be replicable in other settings as the context and participants differ with each social setting (Bryman, 2012; Mertens, 1999). Creswell and Clark (2011) explain the following processes as part of quality control.

- i. In order to compare results of different studies the same data collection processes should have been followed when collecting the data sets which are under comparison. For example, data cannot be gathered using interviews in sample A and then compared to data gathered through questionnaires in sample B. For this research, similar data collection techniques have been used for all the data that was compared to each other.
- ii. The same research objectives must be used in deriving different data collection strategies that will contribute to the main research argument. For this research, the same objectives were followed in deriving the questions in both the interviews and questionnaires for the data collection processes.
- iii. When analysing the data collected using different procedures, we must ensure that the data analysis follows the same themes in order for the data to be interpretable. For this research, both the questionnaire and the interview findings were gathered and then analysed using similar themes.

- iv. Finally, qualitative data can be used to support quantitative data to correlate an argument. For this research, the questionnaire findings have been supported by the participants' interview findings.

(Creswell and Clark, 2011).

2.6 Summary

This chapter on research methodology covers the different methodological approaches that were used to conduct this study. Chapter 3 will now present an overview of the research literature for the area of mobile learning, which in turn provides some of the theoretical background of the research.

Chapter 3

Literature analysis

Chapter 3 presents an evaluation of the research literature which will ensure that readers have a greater understanding of the background to this thesis. We begin by revisiting the South African education system, examining the code-switching process used by learners and the learning challenges that they face, in order to familiarize readers with both the context of our research and the challenges that mobile learning aims to overcome within this context. As the foundation of the mobile learning framework proposed in this research project, the concept of code-switching will also be introduced in this chapter.

Furthermore, after revisiting the key elements of the research undertaken, we review existing mobile learning frameworks and architectures, so evaluating their contribution to research. The chapter then analyses related techniques that enhance learning notably those that give an understanding of learning theories which deal with the cognitive aspects of the development of pedagogical technology.

3.1 Introduction

The research context of this thesis is that of a developing country. Considering this we have concentrated on South Africa through a case study perspective on the challenges faced by schools in this country. The objective has been to show how mobile learning can be used to support learning in similar environments. Such a context was chosen for the research project in view of the numerous challenges faced by learners, amongst others the lack of access to adequate learning resources which also support the languages in which they learn. The choice of the research context was also determined by the high level of learner access to mobile

devices which has become a characteristic of South Africa and other developing countries. Even though the studies presented in this thesis focus on South Africa, the study takes into account lessons learnt from initiatives taken in other countries. Such initiatives will be analysed later in this chapter.

South Africa has a complex language and education system which will first need to be explained to readers. There are eleven official languages in South Africa: Setswana, isiXhosa, Sotho, isiZulu, Sepedi, Tshivenda, Ndebele, Xitsonga, Afrikaans, English and siSwati. Each of its nine provinces uses a minimum of two dominant languages for official communication. English is the official language of instruction in every school (Desai, 2001) . Although English is the national medium of instruction, the government of South Africa maintains that each official language be regarded equally and promoted for use in education and wider communication (deKlerk, 2002; DOE, 1997) .

The majority of South African learners in primary and high school education are bilingual or multilingual learners who only acquire the language of instruction when they begin formal primary education. Despite the high number of bilingual learners in schools, teachers were in previous years rarely provided with appropriate teaching skills to support learners' transition into a second language of learning. Learners in resource-constrained schools often fail to grasp the essential elements of the language of instruction which adversely affects their understanding in different subject areas. Such problems limit their capacity to interpret what is required from them, especially for those subjects that require a clear and precise understanding of a language such as mathematics (Sookrajh and Joshua, 2009). In addition, many of the learners experiencing such difficulties come from communities that do not use English as the primary language of communication.

3.2 Challenges of the South African learning environment

Additional to the linguistic challenges, concerns about fundamental resources affect many schools faced with an inadequate number of up-to-date learning materials, such as text books, or access to digital learning resources. Moreover, the learners themselves may not be able to use a computer as they did not have the skill to do so.

In one of the many attempts to mitigate a lack of digital learning resources, the government has implemented basic computer education and provided computers to some rural schools. While the initiative has been a success for some schools, learners have only had access to limited digital resources due to the cost of allocating computers across the board. Moreover, schools not only have a limited number of computers but a limited number of teachers with a computing education. In some rural areas, the government has introduced community computer labs. Unfortunately many rural teachers lacked the technology skills that would allow them to impart knowledge through the use of computers and digital resources (Dlodlo, 2009). With the introduction of technology it remained difficult for many teachers to make use of skills that they did not possess, and in some schools the computers were stolen and never replaced. This problem was also accentuated by the lack of network access in rural areas (Ford and Leinonen, 2009). Many remote schools or schools in low income rural areas lack the infrastructure required to provide access to digital resources (such as online learning or e-learning material), while the majority of them do not have computers on site or do not provide Internet access to learners (Dlodlo and Foko, 2012).

These factors have contributed to the low results of learners in their final high school year. The lack of an alternative access both to digital learning material published in South African languages and to appropriate accessible multilingual learning mobile

and electronic resources for learners stand as the two essential issues that motivated this research.

A brief overview of the structure of education in South Africa may explain why current progress in the education system is so slow in yielding an improved quality of results in schools. Previous (pre-1994) South African governments allocated school funding and infrastructure development in accordance both with race and location. The schools in urban areas were well-funded with adequate classrooms, text books and other learning resources, being that most of the learners in these schools belonged to the race favoured by governments. Highly skilled teachers able to support the bilingual nature of learners from an Afrikaans language background were often deployed to urban schools. Schools situated in low income and rural areas had the opposite experience. There was low budget allocation to developing schools within the areas where the majority of the country's black population lived. The schools in low income areas were also allocated teachers who were not well trained, especially in subjects such as mathematics and science (Quan-Baffour and Arko-Achemfuor, 2009). In addition, other socio-economic factors contributed to the problem, such as parents in low income areas not being able to afford to purchase additional learning materials to support learners in schools with poor resources. Up until now, urban area schools continue to outperform rural or low income area schools in terms of quality of results. South Africa's Department of Basic Education continues to reduce the existing educational gap through various interventions such as providing equal resources per school, and training and support to enhance teachers' skills. The government is thus striving towards a solution that is context driven rather than taking a *one-size fits all* approach.

The use of technology as a catalyst towards enhancing the learning process for learners in resource-limited contexts thus requires an analysis of the learners

themselves, the resources to which they have access in this context, the learning environment itself and the factors that affect this environment.

3.3 Multilingual learning in South African schools

The linguistic communication of bilingual and multilingual speakers and learners takes place through a multifaceted process which requires an understanding of the cognitive language processing systems of the speakers. Bilingual speakers are often driven by multiple factors in their use of more than one language for oral communication. One of the biggest influences is the social environment of the bilingual speaker. The greater the significance of the languages in their social environment, the more likely the user is motivated to use both languages during oral communication (Lambert, 1981; Mujiono *et al.*, 2013). The same process also occurs during the learning process; a bilingual learner will use two or more languages to comprehend learning content, by generally using languages used in their social and academic context.

There are various types of bilingual learners. *Compound bilinguals* are people who have attained the skill to use more than one language in their childhood i.e. before the age of six. They differ from *coordinate bilinguals* who attain the same skill at an older age (after the age of six), gaining this knowledge in an environment which differs from where they learnt their first language, meaning that their method of using both languages for learning will differ (Lambert, 1981; Basi *et al.*, 1997) . Compound bilinguals often have correct equivalents of a word in different languages as they gained their second language at a young age. Coordinate bilinguals will try to find a relevant word by understanding the subject context and sometimes use an incorrect word to understand its equivalent, either because they often gain the skill to use the second language in later years of their life or have received poor education in their second language. Therefore, the learners participating in the

studies presented in Chapters 4 and 5 of this thesis form a mixture of both coordinate and compound bilinguals so as to represent learners in general in South African schools (Lambert, 1981) . The range of learners who contributed to this research thus also featured learners from affluent social backgrounds where English remains a popular language of discourse as well as learners from average or low income areas where English is not a common method of communication. Learners from firm English-speaking backgrounds (learners from urban area schools) would be regarded in this research as compound bilinguals, as they are often exposed to the English language at an earlier stage in their lives and become familiar with it before the commencement of their education or after beginning their primary schooling. Their understanding of the language semantics was also thus visible during the research process in the interviews and questionnaires conducted in the different studies presented in the thesis. On the other hand, learners in low income areas, where English was not a popular language of communication and where learners attended poorly resourced schools, can be considered as coordinate bilinguals. These learners often get full exposure to the English language only after beginning their schooling years and rarely gain a strong foundation of the language. We also observed in the research process how research participants from these environments struggled to use the correct words to express themselves when communicating in the English language (Wright, 1993) .

Considering the nature of learning in multilingual environments, South African classrooms have a complex language structure which is unique to its diverse population. Teachers in schools, especially rural and low income area based schools, instruct learners in different languages, switching between local languages and the standard language of instruction. This practice is commonly known as *code-switching*, and allows teachers to teach in the official language of instruction which is English. Teachers may later use local languages to clarify concepts to learners or the process may be the reverse with teachers deploying local languages at the

earliest stage when introducing topics, especially when learners experience difficulties in understanding learning content (Brock-Utne, 2007) .

A similar process is also adopted by learners in these contexts. When content is presented in a language foreign to them within a multilingual learning environment, code-switching learners always refer back to the cognitive repository of their home language to look for a word to best describe what they want to understand or say. They may therefore use more than one language to express themselves during a conversation. This process largely differs from that employed by a monolingual learner who only uses one language to interpret learning content (Ncoko *et al.*, 2000). The extent to which a learner code-switches is affected by many factors, including the age at which the speaker acquires the second language, the environment (formal or non-formal) within which they acquire the language, and the quality of education used to deliver the language learning process (Pfaff, 1979; Poplack, 1988; Mujiono *et al.*, 2013).

Unfortunately, code-switching can also have an adverse effect on a learner's performance in a school context. When a learner is given a task, such as in a mathematics class, they may revert to their home language to translate the task, in order to gain a deeper understanding of what is required of them. Moreover, the learner could revert to their home language to translate the answer to the official instructional language. On such occasions, meaning may be lost in their translation causing them to interpret the task in an incorrect manner or supply an incorrect answer. This problem is particularly common in South African classrooms (Setati and Adler, 2000; Mujiono *et al.*, 2013).

This phenomenon of using more than one language in formal education is not only experienced in South Africa. Moschkovich (2007) investigated the rationale behind learners using more than one language to solve mathematics tasks when the Spanish language is the native language and English is the language of instruction.

In her research she captures the natural aspect of the learner's ability to switch between two languages when attempting questions. She also notes that their choice of language will be dependent on which language provides a better explanation for a particular task.

Furthermore code-switching appears both popular and highly visible in subjects which demand a deep understanding of the Language of Learning and Teaching (LOLT) (Adendorff 1993; Moschkovich, 2007). In learning environments where the LOLT differs from the learner's home language, code-switching plays a significant role in supporting bilingual or multilingual learners. When used appropriately code-switching aids the learners to understand and interpret the learning content by using both their native language and the language of learning and teaching (Setati and Adler, 2000; Ncoko *et al.*; 2000; Fennema-Bloom, 2009).

3.4 Mobile learning as a potential learning resource

The ITU (2013) reported that there was an 89% rate of penetration of mobile subscription in developing countries. This figure reflects the high access and use of mobile phones amongst African and developing country users. The report also reflects on the high usage of prepaid mobile broadband in developing countries in comparison with fixed broadband. Most mobile users in developing countries used prepaid Internet and calling credit for their mobile phone services. These factors motivated the potential use of mobile device as learning platforms in comparison with computers and fixed internet connections.

The government of South Africa has introduced enabling policies which support the different uses of ICT in classrooms. The government has also created different initiatives that support the development of teacher's skills in the area of education technology. Their objective is to enable every learner to be competent in using technology to support their learning process by setting up the necessary

infrastructure to do so (DOBE, 2003). South Africa's government research institution, the CSIR along with other researchers, has also made an advance through a proposed mobile learning curriculum framework which proposes support for teachers on using mobile learning to support teaching (Botha *et al.*, 2012). Various mobile learning projects which will be reviewed in this chapter have reflected the potential use of mobile learning as a learning resource in both formal and informal environments. Mobile learning has been cited as the most affordable means of providing digital resources because mobile learning platforms such as mobile phones continue to be easily accessible and affordable in comparison with situated learning platforms, such as desktop computers. The role that mobile learning can play in under-resourced learning environments includes:

- i. Providing learners with digital learning books and software without having to rely upon paper-based resources which can become outdated or vandalised;
- ii. Providing learners with online access to Internet-based learning resources and applications;
- iii. Providing learners, amongst other resources, with a communication portal where teachers and learners can communicate.

These factors have motivated an investigation into the potential use of mobile learning in the South African context. Mobile learning is viewed in this research as a learning resource which can both bridge the learning resource gap while also providing learners with digital multilingual learning resources. Although much work has been done on creating appropriate mobile learning technology for use in learning environments, there is limited documentation on designing and using mobile learning to support multilingual learning in high schools.

3.5 Mobile learning in research: the mobile learning process and its evolution

Over the years authors have used various approaches to define the concept of mobile learning. No definitive definition thus exists with authors frequently approaching the theory in relation to the context of its use (Kukulska-Hulme, 2009; Kukulska-Hulme and Bull, 2009). Initial definitions of mobile learning (m-learning) have focused on understanding m-learning “as a specialised type of e-learning (electronic learning) that uses a variety of mobile computational devices” (Lee and Chan, 2007: 203). Most commonly, mobile learning was initially viewed as an extension of the concept of e-learning. Traxler’s (2005) comparison of both concepts (m-learning and e-learning) highlights the essential differences between e-learning and m-learning as being the learning instrument, the connectivity and the method of communication in the two approaches of learning. In addition, e-learning has been largely influenced by online education on computing devices where the learning process is confined to a specific location.

One of the first recorded and commonly cited (Lee and Chan 2007) definitions of m-learning was that of Quinn (2000) who defines m-learning as learning that occurs through the support or use of mobile devices. Later, Traxler (2005:262) gives a broader definition of, “any educational provision where the sole or dominant technologies are handheld or palmtop devices”. Two important key aspects can be observed in these definitions: the manner in which the learning process occurs and the mobility of the learning device. Kukulska-Hulme (2009) also emphasizes the importance of mobility in mobile learning, highlighting it as a key consideration in creating a mobile learning environment. El-Hussein and Cronje (2010:20) defined mobile learning as, “any type of learning that takes place in learning environments and spaces that take account for the mobility of technology, mobility of learners and mobility of learning”. This definition continues to identify the mobility of the

technology and the learning process as the most important aspects of the mobile learning process.

Considering these definitions, it becomes evident that mobile learning has introduced mobility to the learning process as a progressive advance on the e-learning process. The introduction of mobile learning not only involved changing the method of education delivery but also brought about a paradigm shift in the method of learning. The role of mobile learning in pedagogy should, however, be driven by pedagogy rather than technology because the mobile device plays the role of enhancing the mobile learning process rather than defining the process (Naismith *et al.*, 2004) .

There has also been a rapid development in mobile learning initiatives across the world. Since the inception of mobile learning, one of the first documented mobile learning initiatives was in the United States where a lecturer in the Department of Music of the Central University of Washington introduced a method of teaching music composition through the use of mobile devices. Here, the platform for design was mini-music software. Students completed their compositions and submitted them for evaluation by means of a mobile device (Kukulska-Hulme and Traxler, 2005) .

In the United Kingdom, the rural institutions of Dewsbury College and Thomas Danby College in West Yorkshire and Bishop Burton College implemented their own form of mobile learning. The main purpose of this innovation was the use of technology to allow learners in satellite campuses to receive the same resources as the learners in the main campuses. For example, one of the classes used mobile pod casts for their English lessons. Learners could also go home after English lessons and review the day's work by listening to audio files of the class. This method made their understanding and pronunciation of English much simpler and quicker to grasp (JISC, 2005).

Al-Fahad (2009) performed a case study in Saudi Arabia to evaluate students' perspectives on the possibility of mobile learning as part of a formal education system. The study took place in an institution of higher education. The results displayed both negative and positive contributions on the part of students. To summarize, students felt that a learning method which is not bound by place was foreseeable and much welcomed. The concerns of most students were that some of them would not have access to mobile devices due to various factors such as affordability. Other issue raised included the worry that a poor network infrastructure would set back the implementation of such an initiative. These concerns may have changed with time as the study was one of the early studies conducted in the research area of mobile learning.

Higher learning institutions have often taken the lead in mobile learning initiatives with for example Shanghai Jiaotong University which introduced mobile learning with the delivery of live education through mobile devices (Wang *et al.*, 2009).

With establishments such as MoLeNET, the Learning Lab at the University of Wolverhampton which were some of the first institutions dedicated to advancing mobile learning research, Europe had become one of the earlier leading continents to present the advancement of mobile learning (Attewell *et al.*, 2009; Thelearninglab, 2009) .

With the international uptake of mobile learning research there has now been advanced mobile learning initiatives throughout the world, advancing research into areas which include amongst others, mobile-assisted language learning which focuses on improving the process of language learning through mobile platforms (TRIF, 2013) and the new approach of providing learning through online support through mobile MOOC (Massive Open Online Course) inspired by the objective improving long distance learning (Parsons, 2014).

In Traxler (2013) the advancement of mobile learning is reflected upon from its origins also reflecting its advancement towards introducing a theory of mobile learning which became the basis on which many successive mobile learning initiatives were built upon. Apart from the dedicated growing mobile learning conferences, there is also the dedicated annual UNESCO mobile learning week that began in 2011, which showcases the development of mobile learning in all continents providing reports that document policies surrounding mobile learning enablement, mobile learning supporting teachers in schools, and mobile learning initiatives supporting learning throughout the world (UNESCO, 2013). These developments reflect the increasing progress that the field of mobile learning continues to make.

3.6 Mobile devices in the mobile learning process

There are various categories of mobile learning platforms. Following the definitions of mobile learning discussed in section 3.5, the most common attribute of mobile learning devices is the ability to provide the learner with a pervasive learning environment. The choice of which platform is relevant for learning is largely dependent on the cost of the device, the features it offers and most importantly the ability of the device to support set learning goals (Naismith *et al.*, 2004). Some initial suggestions for mobile learning platforms included laptops, digital personal assistants, palmtops and the mobile phone. These devices enable the simplest form of learning to occur by using applications that are already available on the device, such as note-taking through basic note-taking applications and simple text messaging of educational content between teachers and learners. The devices differ in price with mobile phones being the most affordable. However, mobile phones only provide limited features to support mobile learning platforms in comparison with other devices such as tablets and palmtops. The cheaper devices pose challenges to the learning process with amongst others poor battery life span

and small screen sizes causing heuristic problems. However, the choice of which device is best suited to the target mobile learning process is still based on the cost of the mobile device and the features which are needed in the mobile device to enable the mobile learning process to occur (Georgiev *et al.*, 2004). With a fast growing mobile device industry, mobile software and hardware have advanced with new additions of tablet computers such as iPads and smartphones enabling advanced wireless and software features that are able to support mobile learning both through basic applications available on the devices and external applications which can be modelled for the mobile learning process. For this research, we consider both feature and non-feature mobile phones as ideal mobile learning devices being that, in comparison with other devices, they are the most financially accessible mobile devices for communities of every description, especially in developing countries (Georgiev *et al.*, 2004; ITU, 2013) .

Mobile phones are considered to be the most affordable methods of providing ubiquitous learning because they are reasonably priced yet providing services that are also available on laptops or location-confined devices (Cavus and Ibrahim, 2009). Features that some people may consider as basic to a mobile phone are now used effectively as support in the field of education. Simple text messaging services have, for example, become an effective way of sending and receiving queries and responses in an m-learning situation (Balasundaram and Ramadoss, 2007).

Mobile phones in the 21st century also display features that were previously only available on large desktop computers and which make them improved platforms to support the process of mobile learning. The advancement of mobile capabilities is also supported by competitive, compact hardware features, ever improving network connectivity and continuously advancing mobile operating systems and software (McCammon, 2009). Over the years mobile phones have moved from being uniquely call and message receiver devices to multimedia miniature computers, with

smart phone as the term used to describe modern feature mobile phones. The average smart phone is now composed of basic desktop computer features such as office tools, email services, wireless connectivity and many other features (Charlesworth, 2009). There are more than seven internationally popular mobile phone brands that competitively advance their product releases to meet the growing demand of mobile phone usage. The availability of wireless Internet and wireless mobile connections, such as Bluetooth, facilitate the link between mobile phones and other systems (Liu *et al.*, 2003). Through the use of basic GPRS and other technologies, videos of college lectures and other learning material can now be accessed by students on their mobile phones (Wang *et al.*, 2009). Suki (2007) has shown that people who regularly use their mobile phones more easily engage in m-learning activities, gaming and other services, in comparison to people who infrequently explore their mobile phones. The younger generation spends the most time on mobile phones making it easier for them to cope with any new additions to the device.

Positive and negative aspects continue to arise in the evolution of m-learning, showing the need for constant improvement in the field. Some issues arising include:

- Mobile devices can be both attractive and distracting in a learning process;
- Differing mobile device sizes limit the functions of the learning software, leading to limitation in the realisation of m-learning as an effective or comprehensive learning environment;
- Initial ease of use and subsequent adaptation to tasks allocated through m-learning, can be a challenge to some learners and teachers in comparison to traditional classroom education (Clough *et al.*, 2008).

Despite these challenges, mobile phones continue to emerge as the most accessible digital learning platforms. In a study undertaken by Foko (2009), the following issues were established in relation to the potential of mobile phones as supportive m-learning tools amongst young South African students:

- Mobile phone use is inevitable amongst both wealthy and deprived communities in South Africa as a result of their wide accessibility and falling prices;
- Most learners prefer a dominant mobile phone brand, a choice which can be influenced by many factors, such as affordability and familiarity with the brand;
- Effective mobile learning environments will be limited to the few learners who have Internet access, cameras and other features available on their mobile phones, in contrast to learners who are limited in their ability to purchase compatible mobile phones;
- Most learners explore the functions of their mobile phones and agree with their potential as mobile learning tools.

These key factors strengthen the underlying argument that mobile phones are relevant m-learning tools that can be used to support learning in an under-resourced environment. Problems of phone accessibility amongst learners and teachers will be progressively overcome as mobile phones companies fight to keep their prices low in the market while improving their features. These developments do not however limit the potential of other devices serving as possible mobile learning devices in relation to the study context.

3.7 Developing mobile learning systems: authoring vs. developed tools

There has been a vast growth in dedicated mobile authoring tools in recent years. These tools offer pedagogy authoring support for mobile device platforms allowing teachers to create learning modules which are accessible through mobile platforms. A wide range of mobile authoring tools exist with electronic learning management system companies extending their product range to the mobile learning areas. Amongst others mobile authoring tools include , Hot Lava mobile, iBook's author, mlearning studio, all leaving the user with a choice of which tool suits their context best (Samuel, 2013) . Another example of mobile authoring is the use of Web 2.0 to design content as teachers can record an audio clip or write learning content and post it on a social networking platform for learners to view as and when they prefer to do so (Cochrane and Bateman, 2009).

Equally, mobile application developers are also welcoming the pressure to provide mobile devices that easily support mobile learning and allow educators to develop their own content through mobile software packages that come with mobile devices or can be downloaded such as note taking applications, presentation applications and many other dedicated applications. Designers of mobile pedagogy must be aware of certain basic facts and requirements when designing the product. Understanding the user's experience of learning on a mobile device is crucial to this process. When users become familiar with learning on mobile devices they find it easier to contribute to the learning process. As mobile device users have the greatest power in deciding which educational site or software application is best suited to them, the challenge rests with the designers to maintain a level of pedagogical quality that will ensure users return to use their technology. Collaboration between computer designers with pedagogical architects is thus

important in making the mobile learning experience improve with time (Chepya, 2007) .

This study considers the development of systems designed under a framework supported by both the systems developer and the teacher. Authoring tools in countries where teachers do not have appropriate skills with limited research time to conduct a study using these tools can be a challenge. However as a long term option, after sufficient training is provided, authoring can allow the teacher to have control of the mobile teaching process by being able to develop modes of instruction autonomously. For this research project we focused on developed applications as opposed to authoring tools in view of the challenges faced by teachers when using technology in their teaching process. As there is currently no technology in use to support learning in the schools represented in the studies (see Chapters 4 and 5), it was important to motivate teachers by obtaining their pedagogical participation in material and approaches with which they were familiar. In using familiar methods with new technology, teachers were motivated to participate and use the technology without the fear of being required to use a skill unaccustomed to them; namely, having to use technology to create their own pedagogical material.

3.8 Mobile language learning related to multilingual support

Supporting multilingual learners requires an understanding of both their linguistic challenges and their approach to interpreting content. As mentioned earlier in the chapter, published research is limited in the field of bilingual and multilingual support for subjects other than language learning. There has also been limited research into bilingual mobile learning. Research into mobile language learning is however connected to the field of language acquisition and of natural language processing, such as machine translation. We will thus use the literature on mobile language

learning and natural language processing to give a background to multilingual mobile learning in this study.

Ma (2013) divides research into computer assisted language learning into two main categories: language programs and language resources. Language programs can be understood as software dedicated to the language learning processes which provide different tasks and exercises to support the learning process. Language resources are supportive resources such as dictionaries and online or offline translation software. In this section we will focus on mobile language learning programs which have been specifically developed for the process of language learning. We will briefly examine the use of translation software as a language resource. These research areas are the only ones closely related to multilingual mobile learning and so enable us to provide a research background to the study undertaken in this thesis.

Mobile language learning

The process of second language acquisition often requires continuous interaction on the part of the learner with the syntax and semantics of her second language if they are to act as an effective support enabling the learner to reach proficiency in that language. Through ubiquitous technology, various achievements have been made in attaining this learning objective. The MELLES (Mobile Enabled Language Learning Eco-System) project (Palalas, 2012) is an example of a system developed to support English language learners in gaining auditory language skills. Here, features available in mobile devices, videos recordings, sound clips and pictures are used to deliver learning content to students. This eco-system also supports collaborative initiatives with peers by providing a resource-sharing platform that enables the learners to communicate continuously. Kukulska-Hulme and Bull (2009) have provided guidelines for researchers in relation to second language learning mobile technology. They established that the ubiquitous nature of mobile language

learning technology can ensure continuous interaction with both the language learning content and the learning environment. By keeping a record of the language learning process, learners are able to come to terms with language differences and reflect on their records in order to learn from this process. Both of these objectives can be achieved through the use of mobile learning platforms.

In literature reviews provided by Chinnery (2006) and Viberg and Gronlund (2012) in mobile language learning. The following innovations, key issues and challenges are raised:

- Mobile devices (especially mobile phones) are easily available to learners with their market price continuing to decrease as a result of high demand and competition amongst manufacturers to keep their prices low. Falling costs have also contributed to the rising quality of features available in affordable smart phones that support the learning process (i.e. wireless connections to support online interactions, photograph and video production, viewing and editing features).
- The use of audio features is a key element in the technology enabling the process of mobile language learning. Through automated audio vocabulary content, learners are able to understand the manner in which the language is spoken, and can thus improve their pronunciation.
- Through divided mobile material, learning content can be delivered in data packages through mobile Internet, SMS, mobile pre-programmed software and other forms of learning material. Such mobile content offers learning tasks and word definitions thus allowing constant interaction with the language learning process.

Access to all of the mentioned advantages is amplified by the ubiquitous nature of the mobile devices which allows learners continuous access to their learning

devices. Nonetheless, technical challenges still hinder the success of the mobile language learning process. Small screen sizes can also lead to the minimization of content viewable on mobile screens. Moreover, mobile phones require constant battery charging as they cannot keep up with the high usage required for learners' continuous interactions. Resources that require the use of the Internet can also be disrupted by interruptions in network connection. There are also the challenges of poor audio recordings and deficiencies in the devices themselves which can hinder the learning process where word pronunciation needs to be clear. The field of mobile language learning also lacks the support of researchers and theories, with very few studies available which exactly reflect on how the learners use language learning approaches and strategies through the m-learning process. The research area is however growing with constant research initiatives (Viberg and Gronlund, 2012).

3.9 Language assistant translation tools and machine translation of multilingual content

Currently a number of translation assistance packages exist which are used to support multilingual content users. Although these tools are not tailored to support mobile learning, the techniques used by the packages can be used to support multilingual mobile learning. In Chapter 6 we looked at a secondary case study to review the work that has been done by the North West University Centre for Text Technology contributing towards providing multilingual content. This project has enabled content to be made available for the support of multilingual content users in South African languages.

The Centre for Text Technology (CTexT) is one of the largest research units under the North West University that focuses on making content available in South African languages. Even though most of their work has focused on producing government

documents and other resources, most of which are currently available in English, they have extended these resources to other language users through technology such as assistive translation support tools and machine translation. The technology used by the institution can be adopted to support code-switching learners by enabling mobile learning systems to support seamless translation from a language to another whenever a language switch is required.

One of the principal assistive translation support tools which have been suggested as one of the features in supporting code-switchers when viewing multilingual options of a word within content is reviewed in Chapter 6. This is an assistive translation tool which has been used to support bilingual speakers who use the website of the CText academic institution. The tool enables users to click over a word they do not understand and view alternative words in other languages. This process is an effective way of supporting the code-switching process, particularly when a user wants to understand a specific word. Machine translation is another method that is used to support the transfer of content from one language to another.

In this research while we do not focus on the research area of machine human language translation we suggest it as a method of translating content that can be used to support multilingual learning content development as an external tool. Once again we also use case studies from the CText as they provide evidence of the English language translation to South African languages (CText, 2013).

Machine language translation is the use of different techniques to automate the process of translating one human language to another. This process can be used to provide speakers of language A with resources that have been published in language B through an automated translation process. There are many existing open source translation systems which require “training” to enable the translation process to occur. Training in the area of machine translation refers to defining the parameters or rules that enable the translation process to occur. The parameters

can be one of the following (van Huyssteen and Pilon 2009) : the use of statistical techniques or formulae as can be seen in Yamada and Knight (2001) ; the use rule-based translation which can be seen in van Huyssteen and Pilon (2009) or a hybrid of these approaches seen in Groves and Way (2005). These parameters define how and when translation can occur through an automated process. Although this process does not guarantee the complete accuracy of the translation process, the process enables large scale content to be delivered to a large number of people and thus has the potential to reduce the digital divide amongst communities that struggle to access multilingual learning resources (van Huyssteen and Pilon, 2009). In the South African context, there is currently no published technology that has been developed to support code-switching learners. However, there are research initiatives dedicated to language in technology which are tackling translation assistance and machine translation through mainly the CSIR and the CText.

The problem is that, in a learning environment, the meaning of content which has been translated through an automated process is often distorted. This poses a significant challenge because learning content needs to be precise to help a learner to understand the content. Even though this process can be used to support learning content development, it still requires the support of a language specialist to review the quality of the content which is ultimately used for learning. For the purposes of this research project, less focus has been placed on machine translation processes as a result of the poor quality of content derived from the automated translation process making the content unusable for learning environments. The process of machine translation is thus only suggested where there are no human translators to facilitate the content language translation process.

3.10 The progress of mobile learning in South Africa

In many developing countries mobile learning systems play a significant role in supporting the learning process. For learners in these environments who are challenged by minimal resources, mobile learning not only provides a learning platform but also provides access to technology and resources to learners from different social backgrounds. Many of the pilot projects and existing large scale mobile learning initiatives in South Africa were driven by a remedial need to tackle problems in the education system. The focus of this research is on mobile learning in secondary school education however references will be made to related research projects across different areas.

The current problems experienced in South Africa's education system have been the main motivation for the majority of large scale mobile learning initiatives that have occurred over the past years. One of the earliest mobile learning initiatives in South Africa was the MELFA project. MELFA is a mobile learning system which supports people with dyslexia. The project originally took place in Denmark, assisting employees within the building construction industry. It was mainly intended to help people with reading problems and dyslexia through the use of mobile technology. The project gave workers guidance instruction and guidance on work related issues. When the project was expanded to South Africa one of the applications developed was MELFA for construction employees. Through the use of voice-enabled mobile technology applications, employees can listen to work material in English or in the South African language, IsiXhosa, which was later added to their project. Assistance was, for instance, provided through instructions on how to use a certain piece of technology related to their construction work (MELFA, 2009).

Another notable initiative was the Dr Maths project (Butgereit, 2007; Butgereit, 2012) by the Meraka Institute, which began in January 2007. The Meraka Institute

as mentioned previously is a division of The Council for Scientific and Industrial Research (CSIR) which is a governmental organisation that supports science and technology research in South Africa. The aim of the Dr Maths initiative was to support high school mathematics learners through tutoring sessions facilitated by volunteer university students. Sessions were communicated through the Mxit platform, which is an instant messaging service used by South African youth. Mxit is a popular platform due to its affordable messaging rates which are incredibly low in comparison with other network charges. Mxit offers a chatroom style service to facilitate instant messaging communication between two individuals (Butgereit, 2007; Butgereit and Botha, 2010; Butgereit, 2012). It also gives users the option of communication with multiple users, and they can access available resources and content through it. When providing one-to-one tutorial sessions, the tutors in the Dr Maths project accessed the system through desktop computers while the learners could access the system from any location through their personal mobile phones (Butgereit, 2007; Vosloo and Botha, 2009; Butgereit, 2012). Another notable project was the MoMath project (UNESCO, 2012b) initiated by the South African government, which involved a partnership with the mobile phone company Nokia. MoMath was similar to Dr. Maths in that learners accessed it through Mxit, the instant messaging chatroom platform. In this project learners also accessed the tool through their mobile phones and could communicate with their teachers for support using this platform. The Department of Education contributed mathematics learning material (exercises and tests) targeted at grade 10 learners which were then made accessible on MoMath. A 2012 UNESCO report judged MoMath to be one of the most successful projects of its type because it had both the full participation of the government and private sector sponsorship. Teachers and learners dedicated themselves to the project with the project achieving funding to sustain it through the participation of private sponsors (UNESCO, 2012b).

M4girls, a partnership between Nokia and Mindset Network, was a pilot project intended to support grade 10 mathematics learners in schools in remote areas. Nokia provided learners with mobile phones that had pre-developed video clips of mathematics lessons as well as games that were derived from their curriculum (Vosloo, 2009; UNESCO, 2012b). However, in this project communication did not take place real time and the project duration was restricted by a cut-off date.

Yoza (UNESCO, 2012b) was another project initiated to mitigate the lack of access to books amongst South African youth. The project provided novels accessible through mobile devices which were available in English and isiXhosa (one of the eleven official South African languages). This project was also accessible through the Mxit platform where users could download the mobile novels. The initiative grew to include a wider range of literature including short stories and poetry (UNESCO, 2012b).

In other African countries similar mobile learning projects have also taken place, namely the project based on the simple text messaging service. Traxler and Dearden (2005) have explored the potential of mobile phones to support education in Kenya by providing in-service training to teachers through mobile phones. They observe that the use of SMS (Short Message Service) is highly affordable to Kenyan mobile users because the service provided proves to be reasonably valued. Like many other African countries, Kenya also suffers from lack of resources in schools. This project was however one of the first of its kind in Africa to illustrate the manner in which mobile devices could be used to support learning (Traxler and Dearden, 2005). Many other individual propositions and mobile learning research initiatives are taking place throughout Africa and the world. Researchers maintain a visionary perspective on the use of mobile learning in the hope that it will eliminate the current problems that Africa faces (Gregson and Jordaan, 2009).

While many projects emerge out of the need to use ICT to improve and support primary and secondary school education in South Africa, there is limited focus on the multilingual aspect for mobile learning users in the country. There is also a notable need for support of software development approaches that facilitate the development of different mobile learning systems to cater for the growing mobile learning support area in primary and high school education.

3.11 The evolution of mobile learning frameworks

Existing mobile learning frameworks all have unique contributions to make to the field of mobile learning. Each framework can be used as a guide to support the development, use or evaluation of mobile learning systems or tools so enhancing the mobile learning process. In this study we will evaluate different frameworks and how their role has evolved in improving the mobile learning process. Later, in section 7.9, we will provide a brief overview of different mobile learning frameworks, evaluating their different contributions to mobile learning.

Pedagogy-oriented frameworks dealing with the development of mobile learning often focus on how the learning process occurs and how mobile learning can be used to support the process. Kearney & Maher (2013) present an example of a framework that names the personalisation, contextualisation and collaboration of the mobile learning process as important components in ensuring a good mobile learning process.

In more technical frameworks, attention is focused to the ability of the technology or device to support the mobile learning process. These frameworks often suggest ways of optimising the mobile technology to give learners a good experience of the mobile learning process. In the frameworks primarily oriented towards technical aspects, there is more focus on taking advantage of the wireless network services,

with wireless features such as Bluetooth services converging with mobile devices and electronic learning to enable the process of mobile learning (Motiwalla, 2007) .

In these frameworks, the learning activities prescribed for a mobile learning system are based on the context of its use. The system can use different adaptation methods to examine the users' current and previously acquired knowledge, their learning aims and objectives, along with the situational setting in order to determine the correct learning content. Zhang *et al.*, (2013) give an example of this type of framework which supports the process of professional learning. The framework enables an adaptation in response to learners' knowledge.

Other frameworks combine both pedagogical and technical perspectives to reach convergence between the use of technology and the teaching and learning theory that supports the mobile learning process. The use of mobile learning technology to understand and reach awareness of the learners' context can be supported by the learning material and learning activities appropriate for enabling learning in each particular context. Examples of these frameworks are given by Yau and Joy (2007) where learning content is used to support the learning process through systems based both on the location of the learner and their learning style. Information from the learner and from the mobile device is gathered and used to enable a personalised mobile learning environment.

3.12 Supporting traditional learning theories through mobile technology

In view of the fact that this study focuses on high school learning, we should consider that traditional learning theories continue to play an active role in how learning occurs in both formal and informal schooling contexts. In this section we will look at ways in which we can model mobile learning pedagogy to support learning in traditional environments. The environmental context of our research

study was one in which traditional practices were used owing to the stringent regulations in force in high school education and the resource challenges that teachers face.

Although new technology may introduce more progressive perspectives on learning theories, modern theories continue to be built on traditional theories. In many high schools, teachers continue to use traditional teaching methods emanating from traditional theories. Developing software to support these environments requires an understanding of these theories as the mobile device plays a supportive role in the learning process rather than merely dictating how learning occurs. In this section we will evaluate different learning theories examining their methodology, their advantages and disadvantages. Later, in Chapter 7, we will examine how mobile learning technology has already been used to support their use in different learning contexts.

Traditional learning theories continue to inform current approaches to education technology design as technology moves towards forming an important part of the formal and informal learning process (Wang & Hannafin, 2005) . Various research papers have presented mobile learning theories (Sharples *et al.*, 2005; Naismith *et al.*, 2004, Shih and Mills, 2007) which stem from traditional learning theories and commonly feature elements of constructivism, behaviourism and cognitivism. In this study we will only focus on the theories commonly used to support mobile learning environments. Other theories include connectivism and task based learning. In an age of growing access to information and knowledge, connectivism refers to the ability of the learner to connect the information to which they have access in order to form knowledge and then map out or connect it together to form a theory. This process involves an individual capacity to take a decision on what information is relevant or irrelevant to the knowledge creation process (Behlol & Dad, 2010).

Although there are examples of many theories emerging from the main paradigms of learning theory, we will take task-based learning as a fundamental theory used to support learning in schools.

Task based learning is often used as an approach in a language learning environment. In task based learning, learners are given a task and communicate each successive step of the task (Fetaji and Fetaji, 2009). The following basic learning steps are followed: (a) the teacher introduces the task to the learner; (b) learners perform the tasks; (c) each learner analyses their own work; (d) finally learners practice their work (Hismanoglu and Hismanoglu, 2011). While different theorists have different perspectives about the theory's origins, task based learning can be seen as displaying both behaviourist learning (Fetaji and Fetaji, 2009) characteristics and constructivist characteristics (Hismanoglu and Hismanoglu, 2011), as with behaviourism your response towards a task is monitored and with constructivism learners are required to create their understanding from a task (Hismanoglu & Hismanoglu, 2011).

Traditional learning

Learners in any learning environment become a focal role player once technology is able to play the role of enhancing their learning process through the intervention and facilitating role of the teacher (Hannafin and Land, 1997). The first step in developing appropriate learning content and activities is to understand the manner in which learning occurs. The function of technology in the learning process should thus not merely be that of a tool of delivering learning content (Peng *et al.*, 2009).

Learning theories have been used for many years to understand the learning process and improve the learner environment by subsequently providing learner-centred content (Shih and Mills, 2007). Learning theories can assist researchers by explaining the cognitive learning pattern of learners and reflecting on ways in which

to develop appropriate pedagogy. An understanding of an individual's cognitive learning approach makes it easier to develop appropriate technology capable of supporting their learning process and motivating them to use the technology effectively (Zamzuri *et al.*, 2012).

For the purposes of this research we focus on the main categories of learning theories which are considered to be the main paradigms of this research field. As we have already mentioned, the theories of behaviourism, constructivism and cognitivism form the foundation of modern learning theories (Ertmer and Newby, 2013) . We will also consider theoretical approaches as means of supporting the development of technology-based pedagogy rather than simply categorising learners according to their learning preference and prescribing which theory suits them best.

Behaviourism constitutes a developmental pedagogy approach that supports learners in acquiring learning through the reinforcement of concepts. Behaviourism is seen as a conventional method of learning being that the learner is presented with knowledge that is to be examined beforehand. Learners are then expected to perform in a fitting manner by answering questions that are presented as expected. It is their behaviour in the response process that is monitored by their teacher. Behaviourism however limits the learner's ability to perform a reflective analysis on the assigned task because both the sets of responses and a manner of reply are expected by the facilitators (Boghossian, 2006). The rationale behind using this theory is to support a learner with activities and knowledge acquisition until the learner is able to perfect their expected tasks. An analogy could be made with a new computer. A new computer comes with memory space but does not have any programs available for use. Upon installation of programs and acknowledgement of the rules to follow when using these programs, the computer is now able to perform its required tasks (Ang *et al.*, 2008). The benefit of behaviourist theory is that

learners are given direct tasks to achieve and react promptly to the achievement of these tasks. Another benefit is that a learner will also maintain the same behaviour whenever they are presented with a familiar task (Nagowah and Nagowah, 2009). Through the use of illustrations, exercise sessions and communication, an application developed using behaviourism is able to reinforce approaches of learning (Shih and Mills, 2007).

Cognitivist learning takes an approach which focuses on how learners cognitively process their knowledge. This theory focuses on how learners create rather than acquire knowledge. In a classroom learning environment, teachers support cognitivist learning by using different methods such as exercises and tests to monitor how learners respond to content and thus create further learning material in line with the challenges that the learners continue to face (Ertmer and Newby, 2013).

Constructivism is the use of experiential and reflective learning (Shih and Mills, 2007). Here a learner constructs understanding from the results gained from their personal attempt at a task. Learners cannot make identical reflections on their process of attempting and understanding tasks as these processes are unique to each learner (Boghossian, 2006). A learner is also trained to build up their knowledge and so be able to resolve tasks, even in unfamiliar circumstances (Ang *et al.*, 2008). Thus, the learner is enthusiastically involved in the development of knowledge (Hunter and Benson, 2007). The benefit of the theory of constructivism is that a learner is able to adjust to any task by reflecting on the ways in which he has tackled previous challenges (Nagowah and Nagowah, 2009). Constructivism can be achieved by providing learners with a topic and requiring them to explore the topic by drawing upon different resources. The learners will later receive instruction on the topic and be tested to create an understanding of the learning content based

upon their pre-knowledge, their post-knowledge and their process of gaining information from different educational sources (Ertmer and Newby, 2013). Table 3.1 below summarises the above learning theories reflecting on their advantages and disadvantages and how they are practiced in classroom environments.

Learning theories	Methodology	Advantages	Disadvantages	Traditional method	Classroom
<i>Behaviourism</i>	<ul style="list-style-type: none"> • Acquiring knowledge through a change in behaviour or response after receiving knowledge from an instructor or teacher. In this learning method, the performance and manner in which a learner responds to a task or content in one or more instances is monitored 	<ul style="list-style-type: none"> • The process of knowledge acquisition can be monitored and supported through observing the change in behaviour when a learner acquires knowledge • Assessment of behavioural learning provides quantifiable outcomes 	<ul style="list-style-type: none"> • Lack of creativity from the learner as the process of learning is controlled • Knowledge is memorised with less focus on the understanding of knowledge 	<ul style="list-style-type: none"> • A teacher provides learners with class notes and gives them a class quiz to monitor the manner in which they respond 	
<i>Cognitivism</i>	<ul style="list-style-type: none"> • Acquiring knowledge through different methods which allow cognitive reflections through the learning process. The mental approaches to acquiring knowledge are monitored as methods of determining how learners learn. 	<ul style="list-style-type: none"> • The understanding of learning content plays a central role in cognitivism 	<ul style="list-style-type: none"> • Knowledge is acquired based on the pre-knowledge that the teacher gives the learner. 	<ul style="list-style-type: none"> • A teacher uses a series of tasks such as class exercises with solutions and test responses to monitor the learners pre- and post- dispositions on a topic. The teacher then prepares material considering the challenges that learners face. 	

Constructivism	<ul style="list-style-type: none"> • Learning which occurs through a reflective process from pre- and post-knowledge creation, from experiences and from influences derived from the context. 	<ul style="list-style-type: none"> • Learners create their own knowledge with more emphasis on reflecting and understanding how they acquired the knowledge. This gives learners an independence and confidence when dealing with future tasks and being able to utilise both content and context in understanding. 	<ul style="list-style-type: none"> • Method needs to be used earlier in a learner's environment as always having to create knowledge becomes a difficult process if it is started at a later learning stage. 	<ul style="list-style-type: none"> • The teacher gives learners tasks which rely on pre- and post-knowledge, on their context and on learning content without specifying how learning should be created. The teacher sometimes provides learners with parameters as to where they can obtain learning resources that will enable them to create their own personal realisation of the learning process.
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Table 3. 1 Learning theories in traditional learning environments (Ertmer and Newby, 2013)

While each theory displays its shortcomings, each theory also displays different roles that support the learning process.

3.13 Summary

This chapter introduced the literature which forms a background to the research. It gave a definition to mobile learning and discussed its rapid evolution. The research context was also evaluated, including consideration of South Africa's education structure and the resource shortages apparent in relation to the technological support necessary for creating a mobile technology enhanced learning environment in every South African school. The bilingual and code-switching nature of South African learners and teachers was explained in the context of creating a mobile learning environment.

The chapter also evaluated different mobile learning contributions through project initiatives. Literature which evaluated mobile language learning and machine translation were assessed as closely related literature which provide a base for previous work as a result of the challenges of limited background on the field of multilingual mobile learning. Mobile learning frameworks were also assessed according to both their contributions and shortcomings in achieving an effective mobile learning environment to enhance the learning process.

Finally, learning theories that support traditional learning practices were evaluated to consider how they can influence the development of mobile learning software. All of these factors contribute towards the development of an effective mobile learning framework that will be discussed later in this study. The next chapter will examine the empirical work for this study. In chapter 4 a multilingual mobile learning system was designed for use by learners to support their learning process. The chapter details the process contributing to the mobile learning framework described in chapter 8.

Chapter 4

Multilingual learning in a formal mobile learning environment

In the previous chapter we provided an overview on the progress of multilingual mobile learning in South Africa and in the world. The following chapter objective is to then see how introducing multilingual mobile learning to support knowledge acquisition would enhance the process of learning. This chapter presents the data analysis of an empirical study. A multilingual mobile learning application was designed for this research with the objective of monitoring the interaction process between participating learners and teachers. The content of the system was based on bilingual mathematics content focusing on simultaneous equations which formed a part of the South African high school curriculum. The content of the application was available to view in two languages namely Setswana and English, with English as the official instruction language. The evaluated information was collected from four high schools in the North West province of South Africa for a period of one month. Through questionnaires and semi-structured interviews, data were also gathered from the participants and from also observing their interaction with the systems through a log monitoring their navigation between the content using different languages. The output data were also further analysed through a thematic analysis and descriptive statistics in order to establish any relationships amongst the findings and consolidate emerging patterns. Before the research project was conducted a pilot project was initially conducted to test the data collection instruments namely: the M-Thuto system which was the mobile learning application system, the interview questions and the questionnaire structure. These results helped me to refine the research instruments used to collect data in the main study to ensure quality results in the research project. The chapter results contribute to the proposed mobile learning framework by providing empirical findings which support the framework approach.

4.1 Introduction

The evaluation of the first model of the M-Thuto application presented in this chapter is assessed for use in the formal learning environment presented in table 4.1. The methods of data collection and analysis have also been highlighted in the table below.

Type of Data	Data Collection Process	Data Analysis Strategy
Qualitative Data	Interviews: Teachers, High school learners	Thematic analysis
Quantitative Data	Questionnaires: High School learners Quiz test results: High School learners, Online system learner log file	Thematic analysis Descriptive statistics Chi-Square test Pearson's correlation test

Table 4. 1 The chapter research process

4.2 The research process

The sample of this research project was made up of 90 learners aged between 16 and 21 years and four teachers from four different secondary high schools from the North West province in South Africa. The sample was chosen based on the permission granted to perform research in the chosen schools. The schools chosen were also targeted because they offered mathematics and science as subjects, with mathematics being compulsory in each school. The significance of focusing on these subjects in this

research is mainly as a result of the poor performances of learners in these subject areas in South Africa (DOBE, 2012). The participating learner's grades or levels ranged from grades 10 to 12 which are the last three years of high schooling in South Africa with average ages of between 16 and 21 years of age. The content of the application to be used in the study was designed to support high school learners. The quality and output performance of high school in South Africa is mainly based on the grade 12 outcome results and thus high schools learners were the relevant population to participate in this study. The province in which the study occurred is dominated by first language Setswana speakers, having the highest population of Setswana speakers in the country. Most of the schools in the province offer Setswana and English as two of the available school subjects. English is the national medium of instruction.

Each school differed based on its geographic location within the province. These locations also played a role in influencing the socio-economic background of the participating learners as outlined in the section 4.3 below. The schools also differed with resources available to learners within the school. Each participating school offered mathematics as a subject and all participating learners and teachers were mathematics learners and teachers. The content of the software developed was also based on the mathematics curriculum focusing specifically on simultaneous equations. As the study occurred in a short space of time, only one topic area was chosen to be included as the learning content. All the learners had been exposed to the topic of simultaneous equations either in the previous year's class or during that particular year of study with this subject forming the leading content of the software.

4.3 School Backgrounds

In order to understand the complexity of the classroom language and education system in South Africa, a prelude which gives clarity to the context of the schools is provided in this section. All schools had the basic needs of classrooms, sanitation and teachers

available to them even though this is not the case for some of the schools in the country. All participating schools are public government schools with multilingual teachers and learners of South African official languages. Furthermore, the North West province where the study was conducted is a predominantly Setswana speaking area and thus Setswana was one of the leading home languages of the participants in this study.

Research Project 1

School A is based in an urban area and was formerly known as a model C school under the previous government regime. Model C schools follow a semi-private structure where extra facilities and subjects which were unavailable in other public schools were practically paid for by the learner's parents. This led to higher payment of school fees in model C schools in comparison with other public government schools with low or non-paying fee structures. Previously these types of schools (model C) boasted, amongst others, good geography and science laboratories, sporting facilities (swimming pools, basketball courts, and other sports grounds) and distinct subjects such as art and foreign international languages other than English which were often unavailable in other non-model C schools. The schools also had an adequate number of highly trained teachers. These schools were previously often attended by learners who came from the minority race and whose parents had the financial ability to afford the schools. Even though model C schools are now open to the general public, most of them do not offer the same facilities and services as they used to as a result of poor administration and other restructuring effects.

In this research, school A is fairly well-resourced and offers a wide array of subjects. These resources include, amongst others, an adequate number of teachers (with an average ratio of 1 teacher to 30 learners) and learning material (including textbooks and class notes) necessary for learning. The school also offers optional computing

lessons with computers available for use only to computing learners. As the school is located in an urban city, school A is 10 km away from national amenities such as the public library and museum. Even though the city does not have free large scale Internet access areas, learners have access to Internet cafes which require a payment for learners to access the Internet facilities, and free Internet from 5 computers in a small national library.

School B is based in a township also known as a location. Townships in South Africa were predominantly known for high crime rates and violence as a result of high poverty rates within those communities. The rate of violence in each location differed per province. Township schools were in the past considered to be unsafe schools as many of the learners attending these schools were known to be exposed to violent environments at home and in their communities leading to violent behaviours in schools (Mampane and Bouwer, 2011). The schools were also poorly resourced in terms of available teachers per classroom or subject, books available to learners, funding and other related problems. This norm that exists about township schools is gradually decreasing as the government aims to reduce the violence in township schools and support previously under-resourced schools with relevant resources.

School B does not have any computers for the purpose of learning and thus offers no computing lessons. There is only one computer used for administration purposes in the principal's office. The school has an average ratio of 1 teacher to 37 learners. Even though townships schools often suffer from lack of resources, unlike rural based schools they are close to public amenities such as libraries and museums with this particular one being about 20 km away from the national museum and national library with 5 computers offering free Internet access in the library.

School C & D are based in rural villages. School C is 30km away from its closest city while school D is over 60 km away from its closest city. Both villages depend on their main city for access to main services such as public libraries and museums. The

schools do not have any computers for the purpose of learning. The only computers (1 per school) are used for administrative purposes by the school leadership. Like many other schools based in rural settings, the school teachers often lived in the main cities and had to travel daily from far to come and teach in the schools as these villages did not offer them competitive and needed services to live in them. The schools faced the same challenges as school B, with lack of an adequate number of teachers per class and teachers who are able to teach subjects such as mathematics, science and computing subjects, lack of adequate learning material and other related resources such as effective science laboratories. In some instances which are now becoming a rarer occasion, there were not enough text books per learner to use for learning during and after school forcing learners to share learning material.

An understanding of the schools in the study gives a reflection on the importance of the research in the area under study.

4.4 The system design process

In this section we describe the M-Thuto system that was developed to support learning in formal learning. The waterfall model described in detail in section 2.4 of the methodology chapter was used to support the software development process of M-Thuto in this chapter, customising it to support education technology design. The model follows the following basic processes: gathering requirements, analysing the requirements, designing and developing the system, testing and implementation.

4.4.1 Gathering requirements

In the requirements gathering process we established the teaching and learning objective, the current practice of learning in classrooms and how mobile learning can be used to support the multilingual learning environment. After consulting with the

different teachers about how they conduct lessons, we define the followed processes in the requirements gathering stage below:

- **Establish objective**

In formal learning environments the teachers' objective was to impart knowledge to learners, engage learners in the process and support the learners by providing them with learning material.

- **Establish the current practice**

The teacher sets out what they are to teach by preparing a lesson plan. The lesson plan is based on the curriculum which has to be achieved in every subject based on the government allocated school time. During class, a teacher introduces topics to learners by requesting them to read on the topic before the next lesson. The teacher teaches learners on a topic using class notes, illustrative examples and tasks from their workbooks while asking them related questions in class. Learners are also expected to note the material provided on the chalk board from the teachers as they teach. After every interval the teacher provides a test or exam to evaluate the understanding of the learners. The learners are also sometimes given different tasks that require them to work together on a topic. The teachers objective is to ensure that learners understand what they are being taught, to help learners create knowledge and to ensure that the learners meet the curriculum goals. The learners learning objective is to understand what is being taught to them while discovering new knowledge in the process. All content from the teacher and from the learners' workbooks is written in English. Teachers switch between English and Setswana while teaching. Learners use English and Setswana to interpret what they are being taught, what is being presented in workbooks and to ask their teachers questions. They also use it to learn amongst each other.

- **Establish new support process**

Develop a multilingual system that enables learners to access learning resources used within their classroom to support the learning process, while enabling the system to support their constant switch between languages while learning.

In the classrooms participating in this study there was currently no use of technology to support mathematics learning as part of the formal learning process. The teaching occurred through a teacher asking learners to go through the next topic which they would begin to cover using their text books and other sources that they had access to. The teachers would then teach in class by providing learners with class notes while asking them questions related to what they were teaching and ultimately monitor their understanding through class tests and later an examination. Throughout the lessons in three out of four of the participating schools the teacher code-switched between English and Setswana while teaching. The learners also code-switched when asking learners questions related to what they were been taught and to interpret the notes and tasks presented to them.

The requirements gathering process reflected that we had to develop a system that will support the current practice of learning, providing learners with access to their learning material and resources such as interactive challenging activities with worked examples, class notes and mobile books. All of the content had to be available in two languages enabling the learners to switch between the languages anytime during their learning.

4.4.2 Analysing the requirements

The systems requirements analysis process revealed the following.

- The teachers use the traditional approaches of teaching which are mainly rooted in the behaviourists and the constructivist approach. Each day teachers prepare a lesson plan for the following day's class. The plan is influenced by what the teacher's aims to achieve with the learners. If they want to introduce a

new concept the teacher provides learners with class notes teaching and asking them questions during class based on what they are teaching. The teachers then provide a class test, exercises questions or an exam to monitor the understanding of the learners. If the teacher wants the learners to understand further what they have taught, the teacher provides learners with a topic based on what she had taught and requires them through group tasks or individual tasks to search for further information on a topic and present their individual comprehension through exercises or presentations. The teachers also always uses worked examples during class which help learners to gain further knowledge by attempting the task and then referring to the answers to check if they had arrived at the same answers as the worked example.

- In formal learning environments code-switching was used to: introduce new topics to learners; to reaffirm what the teacher had already taught in English especially if questions from the learners reflected that they did not understand; to reiterate questions in another language if the learners posed questions which they had not phrased well initially bringing about confusion to the learners about the topic at hand.
- The switch occurring between the languages was often formal and restricted occurring per sentence or after every paragraph.
- In formal learning the teachers use different activities to introduce topics to learners and reaffirm what they had already been taught through, amongst others, class notes and class exercises.
- Challenge – The teachers in all four schools were currently using no technology in class even though a teacher from school A advised learners on YouTube videos and other online learning resources that could assist their learning.
- Challenge – All teachers had no skills to use authoring tools to author their own teaching subject material.

The design of the system thus considered each of these issues. The manner in which language was used in formal environments was restricted and the system design had to consider these restrictions. The design of the system had to consider the current process and support the manner in which activities were already carried out in class without hindering the teaching process. The system had to be designed to support the learners in their learning process based on what they had to learn, while enabling ease of use by teachers without requiring them to provide technical input and instead just provide pedagogical support for the system.

4.4.3 Designing and developing the system

Pedagogical design

Detailed contents of the M-Thuto system are described in section 4.4.4 while this section describes how the content was created. In the four participating schools traditional teaching practices supported by traditional activities were used to enable learning to occur in the formal environments. The teachers introduced topics through class notes and the learners' workbooks. Through this process the teachers engaged the learners asking them questions based on what they were teaching. The learners then had to practice at home what they had been taught in school. In some instances learners were expected to raise questions related to what they were being taught or had already been taught so that their teachers could go over them with the whole class. The learners were subsequently given formal tests and examinations to monitor their progress. The pedagogical design of the system was based on the current practice of formal learning.

Following their conventional teaching methods it was observed that the teachers were using a blend of conventional learning theories to support learners which were then used to support the design process: In the system learners were provided with class notes composed by the teachers (in this case the Head of department for the North

West province along with the teachers inputs created notes for the system) to introduce topics and allow learners to revise what they had been taught following the behaviourist approach. Also following the behaviourist approach, through class tests, the manner in which the learners would answer was monitored by the teachers (Boghossian, 2006). The learners were also provided with exercises that required them to practice what they were taught and reflect on their way of answering looking at worked examples which could only be reviewed once the learners had attempted a question. The learner would then reflect on other ways in which they could have answered the questions. This approach followed the constructivist approach where learners used previous and present knowledge to construct their own reflection of a learning topic (Sharples, 2002). All learning content was then translated by a language specialist before giving learners access to the M-Thuto system. Each page of content had alternative English and Setswana views.

Architectural design

The architectural design of the system followed a basic architecture where the system had a user-interface which linked the user to their profile and access to learning resources. Each individual profile was stored in the database with the learner's records. The M-Thuto system was accessible online through a server. The system architecture is explained in detail in section 2.4.3 of this thesis.

The system interface

The system interface was presented to appeal to users aged between 16 and 21. It included graphical elements such as comic pictures appealing to young learners. The interface was also designed with navigation options which allowed ease of moving between pages as mobile screens are often small and do not allow a lot of content to be viewed on one page. Considering that some learners using the system would access it using low-cost mobile phones, the content and picture use was limited so as

to suit any type of phone. While this age range of learners required active animated graphics, the system was a learning system and it was important to keep learners focused on the learning content, therefore there was less use of animation.

4.4.4 Testing and implementation

A pilot study was conducted to test the system before learners from the four mentioned schools participated in the study which satisfied the implementation stage of the system. The stage of testing was performed through a pilot study with high school learners from local schools. A request was sent out to learners to voluntarily participate in the study after following the mentioned ethical procedures in section 2.3.

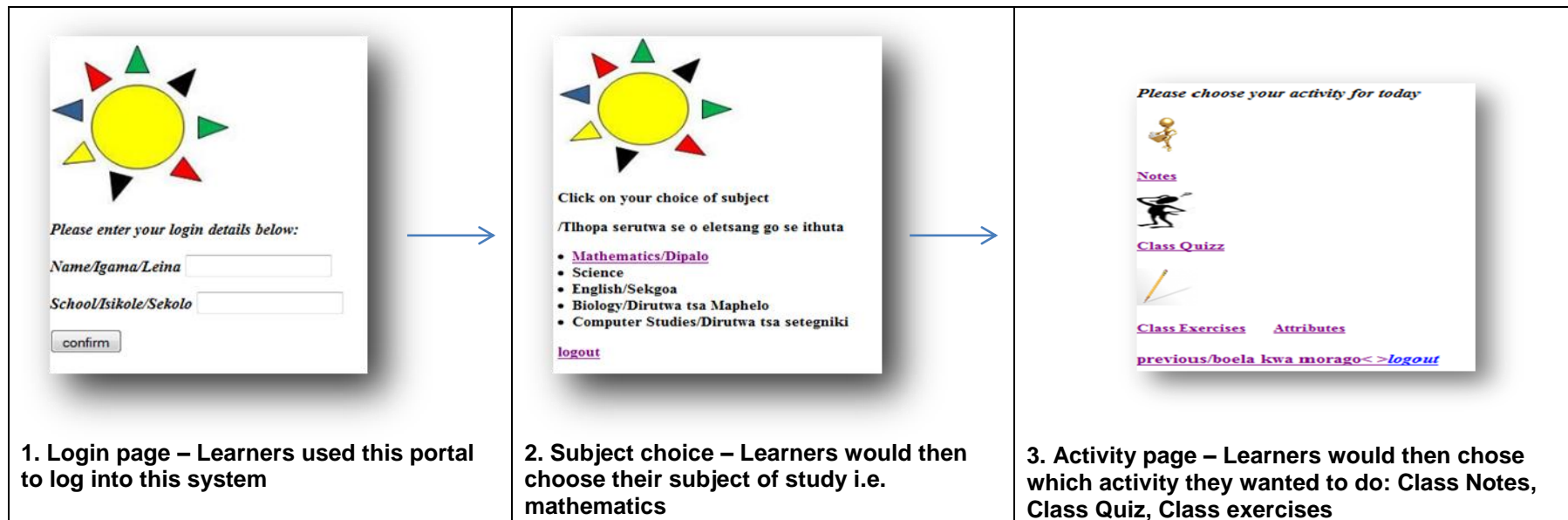
Each participant came with their own mobile phone and after subsequent use of the system gave individual feedback on the system. Results from the pilot were used to improve the M-Thuto system and the interview and questionnaire instruments to be used in the study. The results reflected an increased need of class notes per topic, more animated graphics per page and a need for more subjects such as accounting to be covered in the system. While some of the results were used to improve the system, the system was designed for a short study which only covered the mathematics subject focusing on simultaneous equations. With more resources, the subjects would be expanded to other subject areas and cover all topics under the presented subject.

The system

Learners were provided with learning material and had an opportunity to go through various tasks that enable them to adequately prepare themselves in that topic area. The topic area covered in the learning tool was simultaneous equations that are learnt in the last three years of study for high school learners. Learners each logged onto the system with usernames and passwords which were already stored in the database. The login details were then verified before the learner proceeded to the tool. The tool

consisted of four sections of study as seen in figure 4.1. The sections are explained in detail below.

- ❖ Notes - The first section was a notes section which consisted of related notes formulated by a mathematics department of education provincial (North West province) subject advisor with inputs from teachers. Each page of notes was available in English and Setswana. Setswana is one of the South African languages largely spoken in the area where this research was conducted.
- ❖ Class Exercises – The second section was a class exercise questions page that allowed learners to attempt potential class exercise questions and potential exam questions and later view the correct answer to the questions. The presentations of the answers were extensive providing the learners with ways that they could have attempted the answer.
- ❖ Class Quiz – The third section was a class quiz which allowed learners an opportunity to test their understanding of the topic area. Their answers were sent to the database for teachers to keep track of.
- ❖ Attributes – The fourth section was an acknowledgement section that acknowledged the parties that contributed to the development of the learning content including the translation of the content.



<p>Simultaneous Equations-</p> <p>Notes in Setswana</p> <p>In grade 10, you learnt how to solve sets of simultaneous equations where both equations were linear (i.e. had the highest power equal to 1). In this chapter, you will learn how to solve sets of simultaneous equations where one is linear and one is quadratic. As in Grade 10, the solution will be found both algebraically and graphically. The only difference between a system of linear simultaneous equations and a system of simultaneous equations with one linear and one quadratic equation, is that the second system will have at most two solutions.</p> <p>previous< >main menu< >next</p>	<div> </div> <p>4. This page presents the one of the notes pages presented in two different languages allowing learners to interchange between the two pages</p>	<p>Simultaneous Equations-</p> <p>Notes in English</p> <p>Mo mopahtong o fetileng o ithutile go rarabolola disete tsa di simultaneous equations mo o fitlheleng diequations ka bobedi di le linear(e mmatla kwa godimo e lekana le 1)(i.e. had the highest power equal to 1). Mo kgaolong e, o tile go ithuta, go rarabolola disete tsa di simultaneous equations mo engwe e leng linear and engwe e le quadratic. Fela jaaka mo mophatong o fetileng o tla bona karabo algebraically and graphically. Parologanyo magareng ga linear simultaneous equations le simultaneous equations tse di seng linear ke gore tse di seng linear di tla nna le di karabo di le pedi.</p> <p>tsebe e fetileng< >main menu< >tsebe e latelang</p>
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Figure 4. 1 The M-Thuto system interface

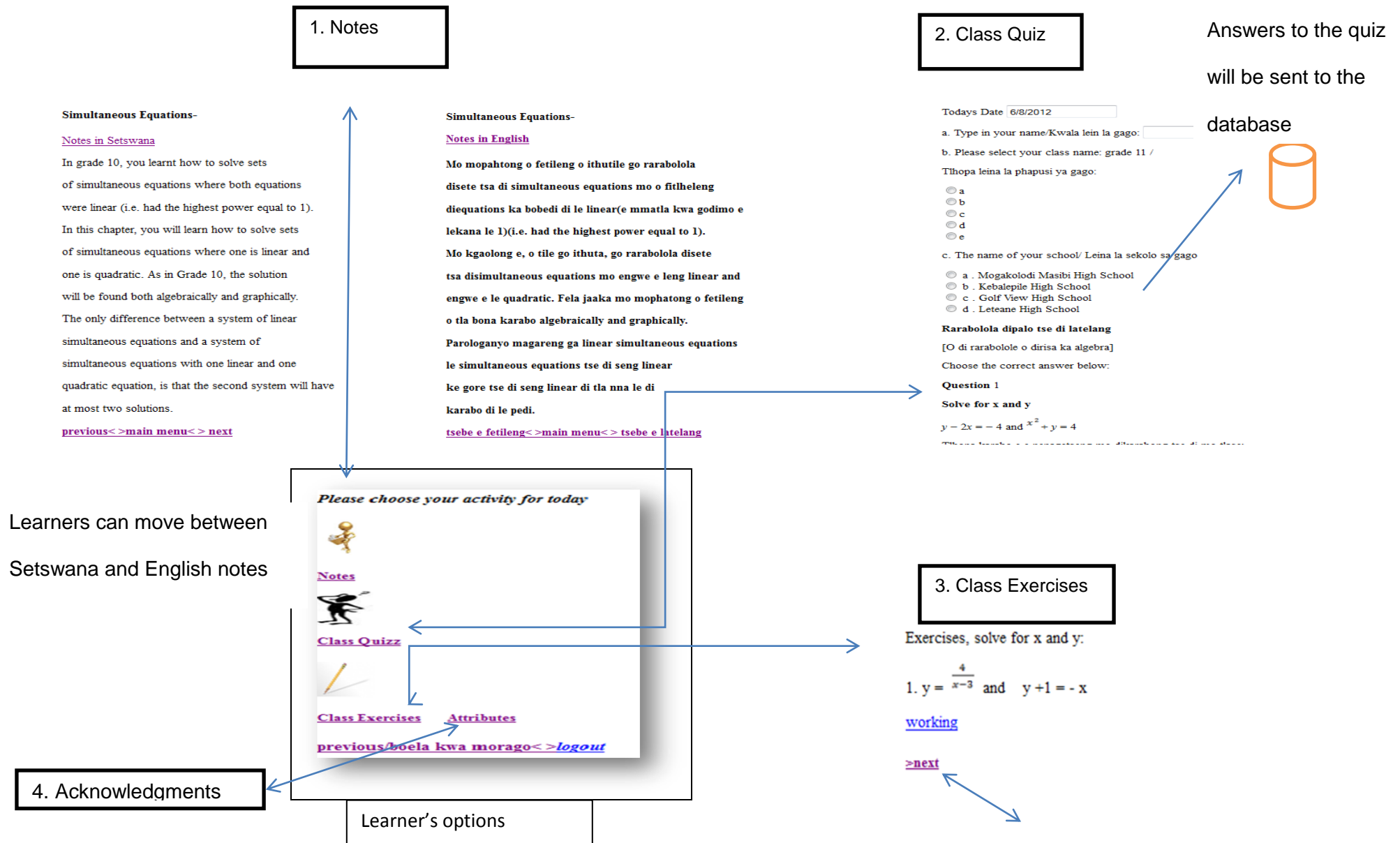


Figure 4. 2 Interaction with the M-Thuto system

Figure 4.1 and figure 4.2 illustrate the M-Thuto system. In figure 4.2 learners had a choice of which subject they would choose. After choosing the subject the diagram illustrates the view of the notes, the view of the class quizzes and the view of the class exercises with worked solutions.

4.5 The research methodology

In this study all learners were provided with basic LG mobile phones which gave them access to Internet facilities. Even though some learners had access to mobile phones at home, the researcher could not guarantee that all learners would be able to bring them to school for the research. Mobile phones are also prohibited in South African schools and thus it was important to consider this rule and instead provide the learners with uniform phones during school hours. Each day, participating teachers gave learners an opportunity to use the system during their mathematics lesson. The teachers also supported the learners by going through the contents with the learners. However records of the learner's interactions with the M-Thuto system reflected that learners used other types of phones such as Blackberries to access the system outside the allocated research time. The learners were taken through the M-Thuto system and given a short explanation on how the system functions. Each learner was given an opportunity to access the M-Thuto system during their mathematics lesson for the period of the lesson and interact with it over the period of the research. The learners were not restricted to accessing the M-Thuto software from home even though the data collected in this study were mainly focused on their interactions during the school class time. Their interactions with the system were monitored and are reported in this chapter. The researcher also observed how many times the learners visited each page of Setswana and English notes observing where they spent more time on each page. The learners also interacted with the system by going through available class notes, exercises and class quiz

(with learners also attempting a quiz). After completing the each class exercise, learners were able to expand the question on the mobile phone and view a full explanation on another method they could have used to best tackle the question with a fully worked solution and text to support it. Learners could only view the solutions once they had attempted the questions. The class quiz was mainly structured in a multiple choice format. The interaction of the teachers with learners while using this system was also observed. Learners engaged the teachers to help them with some of the drill exercises in the mobile system. The learners then filled in a questionnaire that evaluated their perspectives on the system while only 20 of these learners were interviewed, four per school.

4.6 Data analysis method and presentation

In this research the data were reported using contextual illustrations under each theme (Howitt and Cramer, 2008). Cross tabulations evaluating the discrepancies emulating from the learners' different schools settings were also performed.

The data collected during this research process has been reported using similar guide themes as the pilot study. Each theme has been noted below with an explanation of the theme's objective. The data is reported per participating school.

Linguistic, financial and technology background of the learners

- i. The linguistic background of the learners is their ability to read, write and communicate in a language and how they currently used code-switching to learn in formal environments.
- ii. The financial background of a learner is their ability to purchase additional or supplementary learning material that can support them to improve their performance in schools.

- iii. The technology background is their access to mobile phones and computers. This also includes their experience of using electronic learning technology.

Perspectives on bilingual pedagogy and content

- i. Bilingual pedagogy is the availability of bilingual education material and resources.
- ii. Bilingual content is learning material that is available in more than one South African language.

Perspectives on the application experience and ubiquitous learning

- i. Application experience refers to the experience of the learners while using the M-Thuto learning application during the research process.
- ii. Ubiquitous learning refers to their experience of learning beyond the classroom through M-Thuto during this research.

Perspectives on the availability of ubiquitous bilingual learning in mainstream education

- i. This refers to the official national introduction of bilingual mobile learning in and beyond school education settings.

Perspectives on the user interface and usability of the application for the learners

- i. User interface refers to the functionality and the look and feel of the software.
- ii. Usability refers to the software's ability to achieve its objectives of supporting learners in their learning process, providing learners with

supplementary and supportive learning environments that assist them in and beyond classrooms.

4.7 Data analysis of the main study

The data that are analysed in this chapter are based on the statistical data collected through a quantitative approach of questionnaires. The chapter also presents small qualitative data collected through semi-structured interviews and open ended questions presented in the questionnaire. Later in the discussions the findings from the questionnaire study are supported with findings from the qualitative study process. The data are analysed and presented through different themes that aid the author to establish patterns and answer the research question answered by this chapter. Under each theme where individual participant's views were quoted, the views expressed by the participants emphasize their own views and not of the collective unless otherwise stated.

Statistical tests and cross tabulations were also performed through the use of SPSS with the results presented through descriptive statistics and through tables and graphs. During the analysis process we also wanted to establish the following associations.

Are the learner's perspectives of code-switching related to their geographic location of the school? During the interview studies learners from rural based schools were struggling to articulate their views in their responses. The learners from urban school reflected that they do not commonly code-switch. In both geographic locations language was used in different ways with rural schools using more of the Setswana language to communicate and the English language used mostly in urban areas. This helped to establish the different roles that code-switching plays in supporting learners based on how they use or view it in different communities and

school. To answer this question the following hypothesis was established and later tested.

H₀ - The school location of the learner cannot be associated with their code-switching nature

H₁ - The school location of the learner can be associated with their code-switching nature

During the research we also established that there was a difference in the ownership percentages between the genders of the participants. We wanted to establish if there was any relationship between the participants' genders and their ownership of mobile phones. When working with learners it often makes it easier to know which group might have more access in order to balance the percentage of learners' access to mobile devices and we also wanted to understand which group usually has more access. The following hypothesis was established.

H₀: There is no relationship between mobile phone ownership and the learners' gender.

H₁: There is a relationship between mobile phone ownership and the learners' gender.

In this research we also had to establish if indeed learners who have problems of code-switching will use both languages to read the content or just one of two provided languages of content. This was important in understanding if the multiple language presentation was useful to learners who acknowledged their consistent code-switching. To establish if there was a relationship between the learners choice of language view (either English only, Setswana only or both languages) we had to establish if there was a relationship between the learners choice of view and their acknowledging to code-switching. The following hypothesis was established.

H₀: There is no relationship between the learners' choice of language view and their code-switching nature.

H₁: There is a relationship between the learners' choice of language view and their code-switching nature

These associations were tested in the analysis through statistical tests of association which include both Pearson's test of correlation and Pearson's chi-square test of association. The tests were chosen based on the fact that the data displayed properties which the tests require for any correlation or association to be tested on a hypothesis. Each test has a set of rules that determine which data set can be tested using either of them. There are various other statistical tests but as we were only testing relationships between variables, these tests were the most suitable for this data. The Chi-square test is used in this chapter to test if there is any statistical association between the chosen variables which are presented through the above mentioned hypothesis. The Pearson's test of correlation is used to establish if there is a relationship between variables and to what statistical extent does this correlation hold. Similarly the test has also been chosen based on hypothesis which make assumptions that there either is or there is no correlation between the given variables (Bryman, 2012). The data reporting process has been consolidated to give the total outlook of all four schools. However, during the discussions, the schools are sometimes isolated to highlight contextual issues that are important to the research outcome. The findings have been analysed below. Under each theme, the findings are discussed and are also grouped into a gender grouping analysis, school analysis and all-inclusive view of the findings.

4.7.1 Linguistic, financial and technology background of the learners

From the 90 participating learners, all participants were English second language speakers with other South African languages as their home languages, Setswana was however the dominative home language. The predominance of Setswana was also mainly influenced by the fact that the region where the research was conducted was dominated by first language Setswana speakers.

In the four participating schools when asked about their gender (as reflected in appendix A question 3), there was a higher sample size of males in comparison with females with 51% being males while 49% were females. The difference in the gender participants grouping was found to be marginal and could not have a significant influence on the results.

When asked if learners had a problem of understanding content because of the language it was presented through (as reflected in appendix A question 10), a total of 47% said they had a problem while 53% of learners answered that they had no problem in understanding the learning content as a result of the language, this is illustrated in the graph presented in figure 4.3. When analysing the data further through gender, 53% of female learners stated that they had a problem in understanding content as a result of the language in which it was presented through, and the remaining female learners reflecting that they were never challenged by understanding content as a result of the language. In comparison with male learners, only 48% of them stated that they were having trouble understanding content as a result of the language. Even though the differences were marginal, more females expressed that they experienced challenges in understanding the learning content.

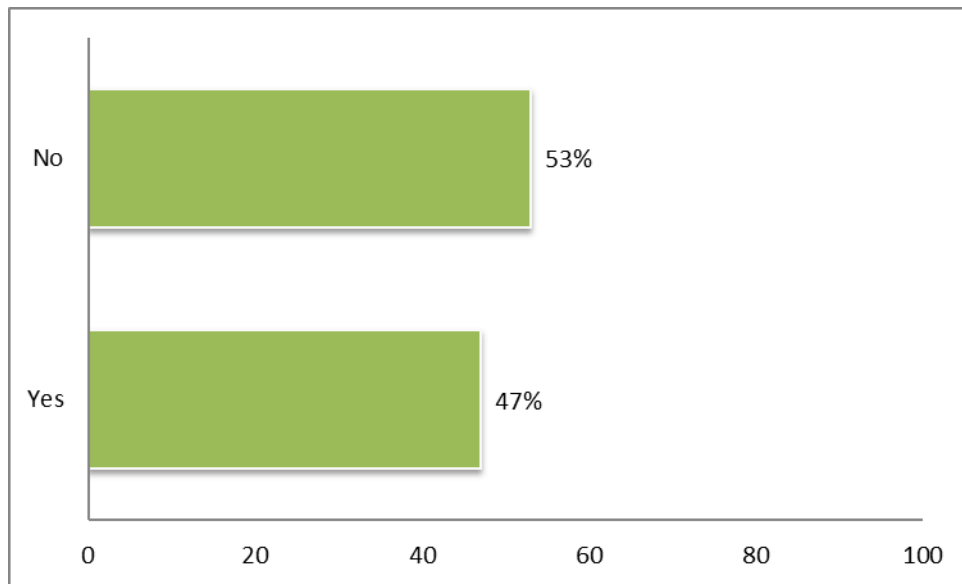


Figure 4. 3 The total percentage of participants who had problems in understanding learning content as a result of the language it was presented in

The next question aimed to establish how many learners would code-switch while learning (which is reflected in appendix A question 13). The nature of code-switching signified their challenge of communication and learning through the language of instruction without having to use their home languages in the process. The learners were thus asked if they ever code-switched during lessons. The results illustrated in figure 4.4 below reflected that a total of 62% of the participants code-switched during lessons while 38% of learners reflected that they had never code-switched while learning during lessons. When analysing the data further, 54% of all participating females code-switched while learning in comparison with 45% of males who code-switched. Once again more female learners had more challenges of learning through the language of teaching and learning.

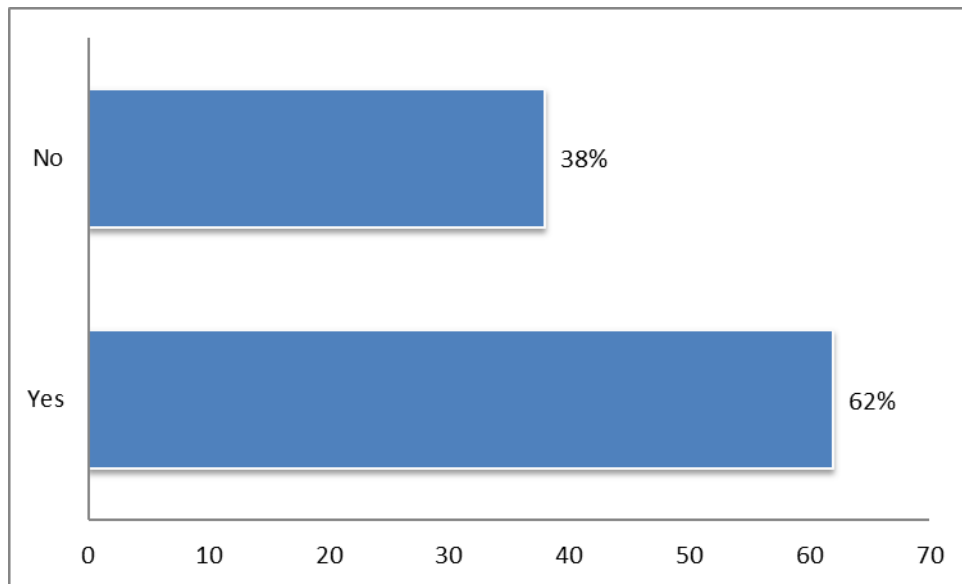


Figure 4. 4 The total percentage of participants who code-switched while learning during lessons.

Schools grouping analysis

The data was also further grouped into schools to analyse the responses based on the school location. Referring back to the question: *do you have difficulties in understanding learning content through the language of instruction*, the data also revealed that there was a difference in the responses to the question when analysing the responses per school. Illustrated in figure 4.5, the rural based schools (schools C and D) had the highest percentage of learners answering yes to having this problem with 67% of learners, followed by the township based school (school B) with 60% then the urban area based (school A) with 42%.

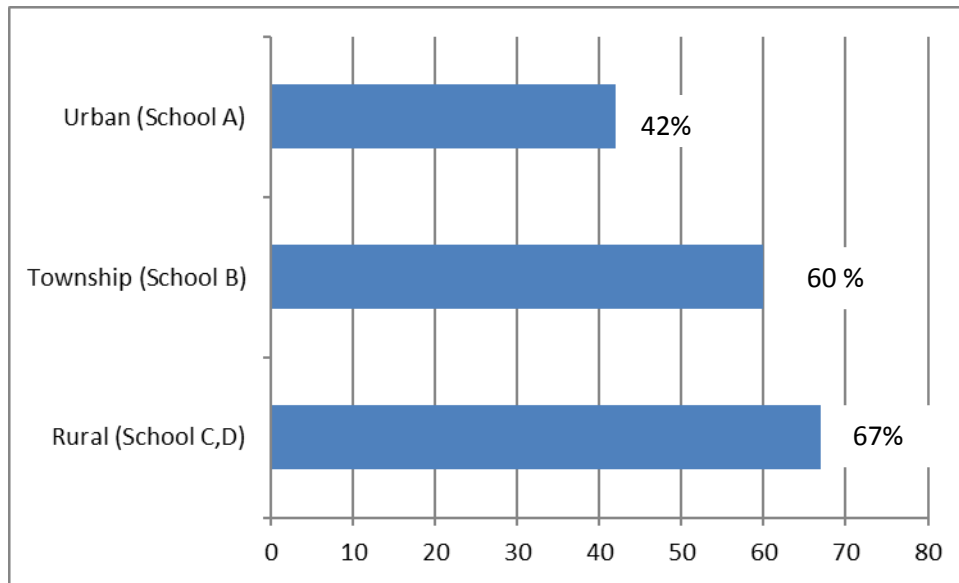


Figure 4. 5 The individual results in percentages per school, of learners who had a problem understanding content as a result of language

As mentioned earlier in section 4.7 when defining the hypothesis to be tested, during the interview process learners from the school A were fluent in English in comparison with learners from schools C and D. The interviewed participating learners also revealed that school A learners often have more training and good English language foundation classes in the English language and thus could communicate well in comparison with their cohorts. When asked if learners code-switched while learning in lessons, 81% of learners in rural schools (school C and D) stated that they do code-switch, compared to only 63% of learners in school A as illustrated in figure 4.6.

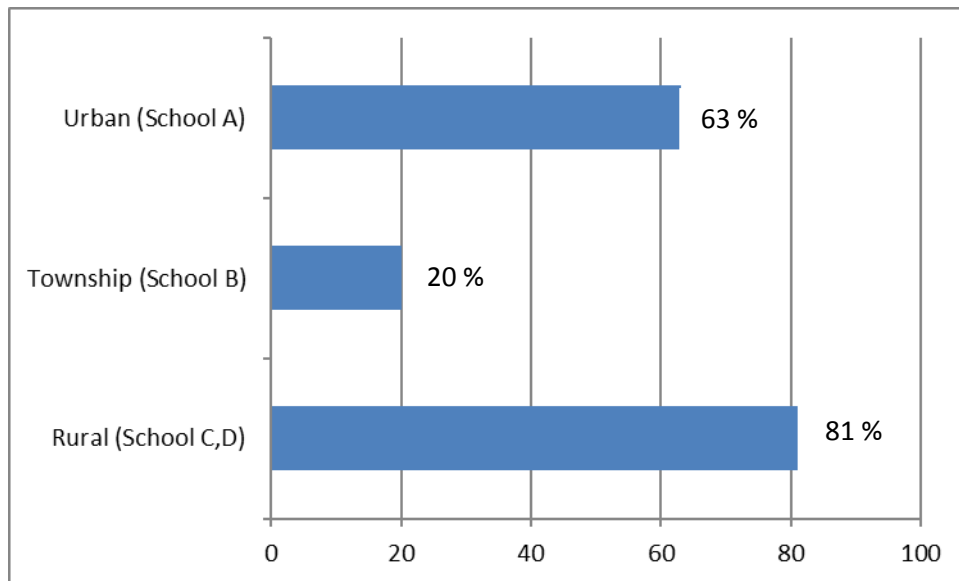


Figure 4. 6 The individual results in percentages per school, of learners who code-switched while learning during lessons

In figure 4.6 we note that in the township school (school B) there was a very low percentage of learners who code-switch while learning during lessons. This was influenced by the fact that their teacher was not a South African and the learners could not code-switch as the teacher could only teach in the English language.

When evaluating the responses of learners with regards to having a problem in understanding content due to language and acknowledging to code-switching, there was a rise in the participants who admitted to code-switching in comparison to the learners who admitted to having problems learning using only one language when looking at figure 4.7.

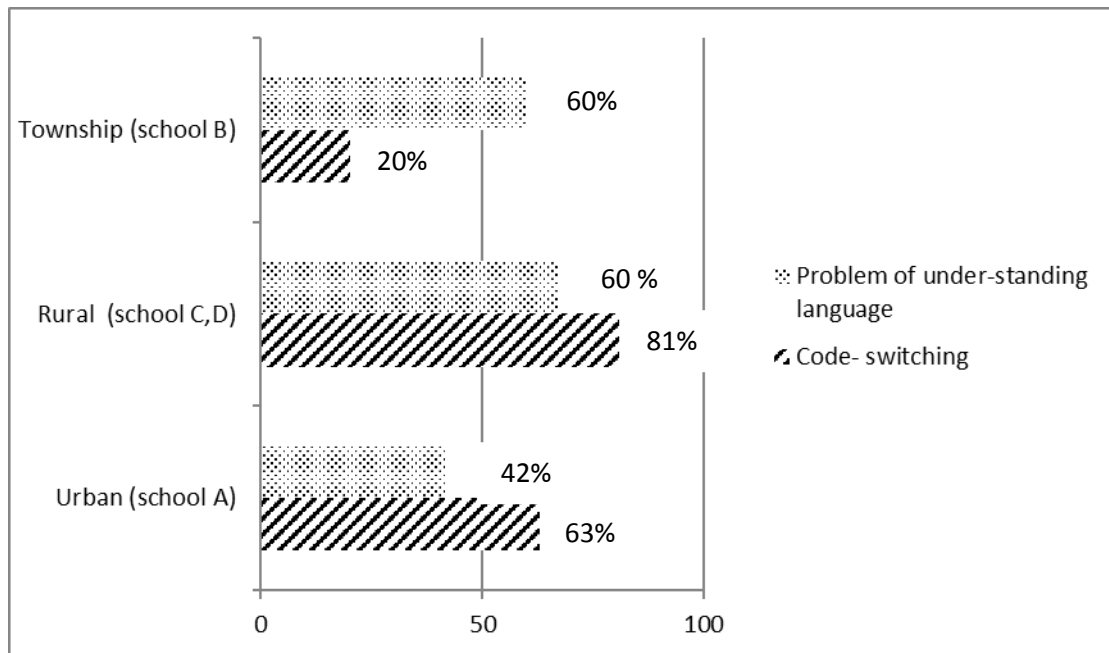


Figure 4. 7 The percentages of learners who had problem understanding language as a result of the language it was presented and learners who code-switch per school

Figure 4.7 results report a high rise of learners acknowledging that they code-switch in all schools when compared to the responses of learners who acknowledge having a problem of language when learning. The learners in the township based school (school B) were not code-switching in class as previously stated, their teacher could not communicate in any of the native South African languages

In analysing these data further, learners from school B who are based in a township, will be excluded reducing the sample size to 65 as they did not code-switch during lessons. Using a cross tabulation between the different groups of participating schools, a Pearson's test of correlation was used on the data to further establish if there was any association with the learners geographic backgrounds and their code-switching behaviour. A hypothesis was thus established to test any association between the two.

H₁ - The school location of the learner can be associated with their code-switching nature

H₀ - The school location of the learner cannot be associated with their code-switching nature

Correlations			
		Codeswitch	Schoollocation
Codeswitch	Pearson Correlation	1	.418**
	Sig. (1-tailed)		.000
	N	65	65
Schoollocation	Pearson Correlation	.418**	1
	Sig. (1-tailed)	.000	
	N	65	65

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4. 2 A Pearson's Correlation test between the learner's school location and their code-switching behaviour

Using SPSS In table 4.2, we found that the correlation coefficient is 0.418 which signifies an existing correlation between the two variables (the learners code-switching behaviour and their school location) with the p value greater than 0.0001. The null hypothesis was rejected for this test. We can conclude that there is an association between the learner's school location and their code-switching behaviour, however these results do not assume causation of the other i.e. Learners from location A will code-switch. A larger population of schools would need to be sampled to establish the relationship degree further.

Finance

Even though all participating schools were public/government schools, an average learner in school A was expected to make an annual payment of R3500 of school fees which is equivalent to an estimated £250, while learners in school B, C and D

would be expected to pay around R350 which is an equivalent to an estimated £25. Schools such as school A would supplement their education with subjects and resources that are not available in other schools in order to give learners an enhanced learning environment. The learners who attended school A could also mostly afford supplementary learning materials that supported their learning process. Most of these learners live in the surrounding urban area with families having high income rates. The further away the school was from the city the lower the income bracket of families. Justifiably, schools in low income areas often produce low results especially in subject areas such as mathematics and science as they also lack resources and teachers adequately trained to facilitate these subjects. Spending extra money to purchase learning material or access to online material can be a challenge for learners in schools B, C and D as most of their parents can only afford to cater for their basic needs.

During an interview with Mrs Legae from school D, she reflected that engaging parents in activities that require additional costs often discourage parents from actively participating in the school. The schools keep additional cost requirements to a minimal and have to look for other means to supplement their needs. She pointed out an example of a recent career fair where learners could not afford to attend as it was held in a city 40 km away from their school. The school had to raise funds through asking for donations and in other ways to enable learners to attend this trip (Jantjies and Joy, 2012).

Technology

When evaluating the technology resources the participating schools had disparities in terms of technology resources with only 22% of learners stating that they had access to computers in school when asked if they had computers in schools (as reflected in appendix A question 16). Furthermore (in question 26 in appendix A)

more than half of the participating sample of learners stated that they were at times given tasks that required the use of technology such as either typing their homework or searching the Internet as part of their homework (Jantjies and Joy, 2012).

When asked if the learners owned a mobile phone (in appendix A, question 17 and 27) total percentage of 48% of learners however owned a mobile phone, and all learners had access to a mobile phone. From the mobile phones owned, most of them were on a pre-paid plan, as most South African learners cannot afford contract plans (Foko, 2009). This also reflects that most participating learners would have to purchase airtime in order to make a call or use their mobile Internet. Currently South Africa has one of the highest Internet rates in Africa making it expensive for learners to access the Internet through their own funding. However mobile phone Internet signals have improved significantly, with villages and remote areas in the country having better access to mobile Internet. The mobile Internet prices have also proved to be considerably affordable as less data is presented on mobile phones as opposed to traditional desktops.

When analysing the phone ownership data further, more females owned phones in comparison with male participants with females at 53% and male learners at 47%. The following hypothesis emerged to test the data further:

H₁: There is a relationship between mobile phone ownership and the gender.

H₀: There is no relationship between mobile phone ownership and gender.

Using the chi-square test of association the above hypothesis was tested with the aim of establishing if there was any association between mobile phone ownership and the gender of the learners.

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.304 ^a	1	.253	.367	.201
Continuity Correction ^b	.706	1	.401		
Likelihood Ratio	1.320	1	.251		
Fisher's Exact Test					
Linear-by-Linear Association	1.284	1	.257		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.89.

b. Computed only for a 2x2 table

Table 4. 3 A chi-square test between the learner's gender and the mobile phone ownership rate

The SPSS results in table 4.3 reflected that the value of p was less than 0.05 which signifies a significant relationship between the two variables which are the learner's gender and their mobile phone ownership. We can thus say that there was a relationship between the learners' gender and their mobile phone ownership

Despite the low percentage of ownership amongst all participants, all learners either owned or had access to a mobile phone with most of these phones having WAP facilities. This reflects the increased market demand for mobile phones which decreases the cost at which we acquire mobile phones with useful features such as WAP. This also bypasses the issue of access to a technology learning device making mobile phones the primary potential method to bridge the learning material challenge.

In terms of mobile educational experiences (based on appendix A questions 20 and 21) only 54% of learners had previous experiences of playing mobile games or using mobile applications with only 38% of these systems being related to their current school content.

4.7.2 Perspectives on bilingual pedagogy and content

All of the participating learners stated that they were at least bilingual with some learners being multilingual. This meant that they could read and write adequately in more than one language. Apart from learners in school B, all other learners stated that their teachers regularly code-switched between English and Setswana while teaching. The teacher in school B was a foreign national and could thus only communicate in English. The perspective with regards to code-switching differed with each school.

While interacting with the M-Thuto application when asked which languages they used to view content (as reflected in appendix A question 30), 61% of learners from all schools used both English and Setswana to view the content while only 34% of them only used English to read the content with none of the learners attempting to view the content through Setswana only. One of the other factors that could have also influenced the results was that the content was only available in English and Setswana while not all learners were first language Setswana or English speakers as some learners spoke other South African languages and some learners came from other African countries and spoke other international languages.

School A had the highest percentage of learners reading the content through the English language only. Contrary to this, school D had the highest percentage of learners using both languages to read the content. It was also noted that in relation to this, from the interviews, Interview Participant A and B both from school A, had a negative attitude towards learning through their home languages as they felt 1. They

had no formal education of the Setswana language making it difficult for them to understand it. 2. They felt no need to learn through Setswana as it was not an international language.

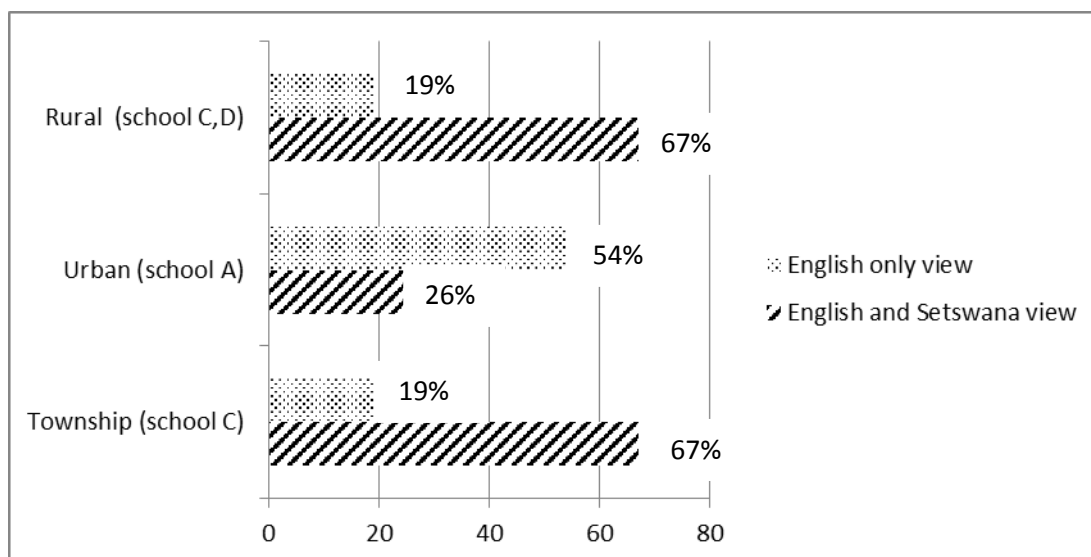


Figure 4. 8 Language view of either English only or English and Setswana per school location

In the graph presented in figure 4.8 the results reflect that the learners in the rural location (school C and D) had the highest percentage of views of the content in both the English and the Setswana language. The results also reflect that the English language was commonly used in the urban school (school A) with the urban school having the highest percentage of participants reading in only the English language. The data was further tested to establish if the learner's code-switching behaviour had a relationship to the language they used to view the learning content. The following hypothesis was tested though a chi-square test of association:

H₁: There is a relationship between the learner's choice of language and their code-switching nature

H₀: There is no relationship between the learner's choice of language and their code-switching nature.

Chi-Square Tests					
	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.452 ^a	1	.502		
Continuity Correction ^b	.155	1	.693		
Likelihood Ratio	.448	1	.503		
Fisher's Exact Test				.583	.345
Linear-by-Linear Association	.444	1	.505		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.79.

b. Computed only for a 2x2 table

Table 4. 4 Chi-square test of association between the learner's code-switching response and their language viewing choice

The results reflected the value of p in the above test in table 4.4 to be p less than 0.05 which means there is a significant relationship between the variables (the learners' language of view and their code-switching nature). Assumptions can thus be further made that the choice of language views will be affected by the fact that learners code-switch thus needing the code-switching support. From the interview process it emerged that some of the learners in schools B, C and D appeared to be uncomfortable with having to boldly pose a question in English in class. Learner M from school B expressed that, 'It is sometimes difficult to understand the teacher as she only speaks English. I sometimes want to ask a question using Setswana but she would not be able to understand as she is from another country.' This particular

teacher she referred to was her maths teacher from Zimbabwe who could not communicate in local languages.

The concept of bilingual pedagogy was new to all learners even though they had been practicing bilingual learning without being aware of it. Learner M expressed, 'I think the languages of the software need to be increased to be available in all South African languages and we should have more options of subjects too'. The learner wanted the application to be available for their other school subjects. For some of the learners, their lack of confidence in English opened up their minds to the concept of bilingual technology designed to support a learner that code-switched. Learner J from school D felt that, 'Having my school material in other languages would be helpful especially for subjects that used a lot of difficult terms. Mathematics is often easier to understand as there are not many difficult terms used in it but other subjects are not so easy.' Even though all learners welcomed the possibility of having pedagogy available in more than one South African language, they felt that translating all existing material to other languages would take long. Considering the fact that most learners from the urban school (school A) used only English to read the learning content while most students from rural schools (school C and D) used both English and Setswana, we wanted to establish if there was any relationship between the school location and the choice of language to read the content:

The following hypothesis was tested:

H₁: The school location of the learner can be associated with the language they choose to read content in.

H₀: The school location of the learner cannot be associated with the language view they choose to read the content in.

Correlations			
		Schools	View
Schools	Pearson Correlation	1	.361**
	Sig. (1-tailed)		.002
	N	62	62
View	Pearson Correlation	.361**	1
	Sig. (1-tailed)	.002	
	N	62	62

** . Correlation is significant at the 0.01 level (1-tailed).

Table 4. 5 The correlation test between the learners school location and the language view

Using the Pearson's correlation test the value of p was greater than 0.05 which signifies a correlation between the learners' school location and the languages they will choose to view the content. Based on these results from table 4.5, we could then assume that learners will also choose a language view to support code-switching based on where they went to school.

4.7.3 Perspectives on the application experience and ubiquitous learning process

There were a total of 54% learners who had a previous experience of using mobile pedagogy (as seen in appendix A question 20) prior to the research. Evidently the urban school (school A) had the highest number of learners who had previous experience of using mobile educational applications or games with more than half of these only available in English.

The next step was to identify how many learners found that the application allowed them to spend more time on their studies (through appendix A question 35). 89% of learners felt that having education material on their mobile phones motivated them to spend supporting their learning.

When considering additional usability concerns of mobile learning devices (through appendix A question 28 and question 29), only 11% of learners had trouble inputting through a mobile phone keypad, while only 25% of the learners were uncomfortable with reading content on a mobile screen. These learners did however feel that the font could have been increased giving better visual content.

Even though learners expressed differences during the interview process, the majority of the learners were open to bilingual content. All of the learners felt that mobile content allowed them to read beyond the classroom. All learners were also able to use the application despite their lack of technology experiences.

The learners in school A which is the well-resourced school, had many views about their application learning experience. Learner S felt that, 'The application was easy to use and helpful. But I would suggest having audio content available as learning while listening is often easier than having to read the content.' The learner's views depicted their firm background and experience in technology. All learners were keen on using the application at home even though the use of the system was meant for formal classroom or school based learning. Some of the learners felt that it would be even more useful if all the offered subjects in the school had a similar supportive application as M-Thuto. They suggested that M-Thuto should include other subjects in it. Learner E suggested that, 'It would have been nice if you had created a chatroom where learners can interact and talk about maths and other subjects'. The learners supported collaborative learning and felt it would also improve their learning process. All learners found the application to be a tool that would be helpful in not just having access to learning material but would help them in preparing for exams. Learner F felt that, 'The application was very involving because you would answer questions and get the step by step solution after attempting the question. I would suggest that we could have more illustrated ways of getting to the answers of the question. The program also really challenges you and helps you as you can

correct yourself afterwards.’ The learners also felt that they wanted to use the M-Thuto at home on their own mobile phones.

Some learners during the interview process felt that mobile phones would cause a distraction to their learning process.

However when questioned (in appendix A question 36) about their motivation towards mobile learning in the questionnaires, 94% of learners felt that having mobile material motivates them to learn regularly on their mobile phones.

The quiz test results

In this study not all participating learners managed to complete the quiz. The results of the quiz carried an average test result of 52% with a sample of 40 learners. As this was a short study, the purpose of the test was not to measure their performance but instead to hear their opinion on being able to learn through mobile phones using all aspects of learning including the assessment part of learning. Furthermore this study was not a longitudinal intervention study, as a result of limited resources. The test monitoring was instead an approach of viewing the interaction between learners and multilingual learning content as the data collection process occurred in a short space of time which made it difficult to monitor the learner’s performance before and after the introduction of the tool. With a longitudinal study results can be observed that can measure the performance of learners through an intervention process following an action research method as oppose to an interpretive method.

4.7.4 Perspectives on the availability of ubiquitous bilingual learning in mainstream education

All of the participating learners felt that having ubiquitous content would help them improve their performance by giving them the opportunity to learn as and when they wanted to do so. 88% of the learners also expressed that they preferred to be able

to ask their teachers questions in real time through the mobile learning application even though this system did not provide the platform to do so. Throughout the study students also verbally interacted with their teachers asking them questions related to the tasks.

The amount of times a learner would alternate between the same content viewing it in English and then in Setswana was also monitored. The result mentioned in the study will only evaluate the notes pages as they hold the significant amount of bilingual learning content. When evaluating the average learner's interaction with the mobile application the following results were observed:

The average observations for one learner:

There were 10 pages of notes in English and equally 10 pages of notes in Setswana. Over one week on average one learner spent 46 views on the English pages and only 38 views on the Setswana pages.

The pattern of viewership differs per school. The rural based schools (school C and D) had the highest percentages of views on their Setswana pages per day followed by the township school (school B) and the urban based school (school A).

4.7.5 Perspectives on the user interface and usability of the application for the learners

When asked about how the application could be improved in (appendix A question 37), learners had different perspectives with some of the learners being happy with the visibility of the screen and with the mobile phone keypad. Other learners felt that they should have been provided with phones with larger screen sizes. 40% of the learners felt that the application could do with more pictures. Learner J felt that, 'The application needs more educational competitions. This would make studying more fun!' It seemed to me that some learners preferred a gaming approach to learning

where there are incentives placed for the number of questions that they were able to correctly complete.

The learners also expressed the absence of video options in the learning application suggesting that it makes engaging with the application more exciting. The learners spend more time engaging with the application in a formal class setting. The learners furthermore suggested having more languages and presenting the application content engagement towards a more rewards based approach.

Most of the learners felt that it was easy to use and the content was directly related to what they were studying. Throughout the study learners enquired more on how to answer some questions as opposed to how to use and navigate the software. All learners felt that using this application regularly would improve their performances in mathematics.

4.8 Discussion

This chapter aimed to answer the following research question:

Question1: How can mobile learning be used to support multilingual learners in their formal learning process?

Linguistic support

Code-switching in an educational context is often used to either explain or interpret content through the use of more than one language. As shown in studies of Jantjies and Joy (2012) and Jantjies and Joy (2013), this is a common practice in South African classrooms especially in mathematics and science classrooms as the subjects require a deeper understanding of the language of teaching. In this research study, participating learners were first language Setswana speakers with some learners reflecting other South African languages as their second language.

To all of the participants, the English language was either a second or third or even fourth language. The class demographics of the participating students also reflected the challenges that their teachers have to deal with of having to teach learners from different linguistic backgrounds through one language which is also not their first language. The South African law on language policy in section 6(1) of the South African School Act of 1996 states that, “the facilitation of national and international communication through promotion of bi- or multilingualism through cost-efficient and effective mechanisms, to redress the neglect of the historically disadvantaged languages in school education.” (DOE, 1997:2). The Act effectively makes provision for the use of more than one language for learning and teaching in classrooms. While there is policy and equal practice supporting the use of code-switching to enhance learning there is an absence of electronic and mobile learning resources to do so. In the four participating schools in the study presented in this chapter, a total of 62% of learners reflected that they code-switched during their lessons. This was a contradiction to their initial responses to the question of if they felt they had a problem in understanding content through the language that it was being taught in. Initially a total of 53% of learners felt that they did not have a problem of communicating and learning in the language of instruction with fewer females admitting to not having this problem in comparison to males. The contradiction arose when these learners were further asked if they were code-switching while learning in class when the percentage of learners who admitted to code-switching rose to a total of 62%. The significant increase in percentage in the second response with learners admitting to code-switching can be attributed to learners being unable to relate the language communication problem to the behaviour of code-switching. Another problem can be related to the perception that learners in urban areas had about admitting to code-switching and learning through their home languages. Even though learners from school B were omitted from this question as their teacher was a foreign language speaker and could not code-switch, the

majority of the learners and their teachers reflected their practice of code-switching in class.

These results reflect the importance of bilingual content to support code-switchers as more than half of learners in the context relied on more than one language to interpret learning content. When looking at the data further to analyse this problem the highest percentage of learners who admitted to code-switching came from rural areas. The learners in the urban areas, similar to their interview responses felt that bilingual content was a secondary support and did not play a vital role for them. The Pearson tests of association between the learner's school location and their code-switching behaviour reflected a significant correlation, as learners in urban areas were probably less likely to use bilingual support. Even though the perspective of bilingual support differs on the school location, bilingual content proved to be important in the learning process for most learners in both urban and rural schools despite the different views.

When evaluating the number of learners who used both languages to view learning content instead of English or Setswana only, the under resourced school scored higher with the percentage of learners using both languages to read the content presenting 83% for school C and 70 % for school D. The benefits of having more than one language give a much larger audience of learners the opportunity to learn and compare and understand learning content. Additionally it also allows a learner to advance their language skills in both of the languages in which content is presented.

Recent South African education quality results (DOBE, 2012) have reflected the adverse effect of the learner's poor interpretation of learning content as a result of being unable to interpret the learning content. Considering the pressure that government has now placed on schools on the use of native South African

languages to support the learning process, multilingual mobile learning is able to provide support through multiple language views presented in the M-Thuto system with alternatives of translation features which will be discussed in chapter 6 embedded within the system.

Resource support

The data from the interviews in the research collected resembled a great disparity of earnings between parents in urban areas and parents in rural areas. Parents from rural schools as mentioned by one of the participating teachers, Mrs Legae, cannot afford to spend further money on purchasing further material for learners. Considering the challenges mentioned by Dlodlo & Foko, (2012) of inadequate text books in schools, learning becomes a difficult process for such learners. While parents in urban areas can afford to supplement their children's learning material with other resources that require further payments parents in rural schools cannot afford to do the same. However, under-resourced schools constitute the majority of schools in South Africa. This disparity does not only exist with the parents of learners but it also exists in the schools. South African government schools differ on the resources available to them. Former government schools were allocated resources and funding according to the race of population attending the school with urban or model C schools receiving the most resources and funding. The effect of this is still experienced as urban area schools continue to have the necessary resources for learning and teaching. Schools are still challenged by the 1)high class ratios – leading to learners not getting the effective attention of the teacher 2)lack of parents involvement in children education finances, 3) the unavailability of adequate learning and teaching resources, including libraries, workbooks and experiment equipment. These are just some of the limitations of the government leading to the low education state in public schools in the country especially non-urban based schools. With most adults in rural communities either unemployed or employed as

domestic workers, gardeners and other low-income related jobs, the learners' parents often struggle to provide them with basic necessities of life. Activities or resources in schools that require them to financially spend on their education become difficult for these communities to support. Furthermore the schools which they attend offer limited resources with a common shortage of teachers in key learning areas such as mathematics and science. Rural based schools are often far from the main cities limiting learners on access to public libraries or Internet and computing centres. The first process in supporting a learning process is to equip the learners with basic resources. While school A in the research study was well resourced in terms of providing learners with resources for learning such as adequate text books and computers being available in the schools, school B, C and D were not able to provide equal resources. The information above suggests that learners still face a shortage of and a need for adequate learning material. Considering the disparities in finances mobile bilingual learning resources presented through the M-Thuto system would enable a uniform access of additional learning material to learners across the environment. M-Thuto was designed using the current practice and using the material that learners would otherwise need different types of resources to access (books, online sites, teacher's notes) providing one access point of all of these resources. This reflects the role that multilingual mobile learning can have in providing learning resource support in formal environments. Learning activities can also be supported by designing them for mobile learning use by supporting traditional teaching practices.

Technology support

School A in the research study produces some of the best quality matric (the final high school year) results, with a high number of A scores in its local district area. The learners in this school had adequate text books per learner, teachers with adequate teaching resources and computer laboratories. In their home

environments learners also had access to further supportive learning material. Furthermore the learners had knowledge of existing online supportive resources. In the study 79% of learners reflected that they either owned or had access to a mobile phone with 48% owning the phones. The learners in school A had 100% ownership of mobile phones which only constitute a total of 48% of mobile phones owned in the group of participating learners. This reflects that most of the mobile phones owned amongst the participants were in school A, with more females owning mobile phones than male learners. School A's good performance reflected the importance of providing technology in aiding the learning process. While learners in most of the participating schools did not own or have access to computers they had access to or ownership of mobile phones. Mobile phones and other mobile devices are able to provide technology support in resource constrained environments which enable learners to access the same technology support regardless of their background.

In the study presented in this chapter, when asked about their history on interacting with mobile learning technology, 53% of the learners mostly from the urban school A cited that they had played educational mobile games before. As they were exposed to technology, learners in school A also had knowledge about additional digital media resources that supported their learning process. Their effective use of their mobile phones supported the importance of having supplementary resources to support learning on a ubiquitous tool. With mobile ownership that was above average (beyond 50%) and universal ownership in the remaining three schools, this opened up mobile phones as potential tools that could be investigated as a secondary learning material delivery technology making it an important reason to allow a bilingual ubiquitous learning environment for learners in schools. The learners who had a previous experience of interacting with some form of mobile learning tool. They expressed the view that there was a significant absence of mobile learning technology presented in South African languages.

Considering the development of either immediate or future use, mobile learning applications have the potential to reach a much larger audience as a result of price and ubiquity reducing the existing digital and knowledge divide across schools.

4.9 Summary

Bilingual learning is a common factor in South African schools which is used as a resource to support learning for learners who are not native speakers of the language of learning and teaching. Most of the schools also need access to formal and informal learning resources. Having access to appropriate mobile learning content available in a choice of languages also supports learners in South Africa to enhance their learning process.

The concept of bilingual mobile learning was novel to the participating learners, their general receptive behaviour towards the study and effective use of the system in supporting their learning activities in formal learning, motivates the need of the development of a framework that can be used to support development and use of multilingual mobile learning systems in similar contexts.

The next chapter presents a primary case study which evaluates the second phase of the M-Thuto system designed to support informal learning. The chapter investigates the role that mobile learning can play in supporting bilingual learners to learn in informal environments.

Chapter 5

A multilingual mobile learning system for informal learning

The previous chapter presented an empirical study that was based on a formal learning environment which evaluated how mobile learning can be used to support multilingual learners in formal learning. This chapter investigates the way in which multilingual learners can learn through a mobile learning system in informal environments. The chapter answers the research question engaging with the current process of learning in multilingual informal learning environments and how mobile learning can be used to support this process. Having created an enhanced version of the mobile learning system M-Thuto, this chapter presents a data collection and assessment process of the study, evaluating the interaction process between learners and the system. One school participated in this study using an updated version of the M-Thuto online mobile application. In this study learners recorded audio clips through a basic application that came with their provided mobile phones and uploaded multilingual clips of their class notes, storing and later reusing these notes for study purposes. The participating teacher had access to these notes and was able to give guidance to learners on a topic that they felt the learners may not have understood. The study focused on the process of multilingual mobile learning support in informal environments.

Data about the learner's interaction with the application was gathered through both the software, through questionnaires and semi-structured interviews.

5.1 Introduction

This chapter presents the second evaluation of using mobile learning focusing on an informal environment. Table 5.1 below reflects on the methodologies used in this chapter for the research process.

Type of Data	Data Collection Process	Data Analysis Strategy
Qualitative Data	Interviews: High school learners, A teacher	Thematic analysis
Quantitative Data	Questionnaires: High School learners Online system learner log file	Thematic analysis Descriptive statistics

Table 5. 1 The chapter research process

5.2 The research process

Learners in a physical science high school class were provided with LG mobile phones. As with the prior study outlined in Chapter 4, all the mobile phones were equipped with SIM cards that had pre-loaded calling credits or air-time, so giving the learners uninterrupted access to the Internet. The sample taken for this study came from a small group of learners within one South African high school E with a total of 32 learners. The location of the sample group was determined by the level of access that was granted to perform research in the school and ensure voluntary participation within a class of learners.

Learners were required to develop 'voice notes' reflecting on what they had learnt in the topic area which the teacher was focusing through their mobile phones in

languages they could understand. They then uploaded the notes onto the system described earlier in this chapter. The voice-recording applications were already installed in the mobile phones. The notes were composed in accordance with learners' understanding of the lessons in which they had participated. Knowledge used to create content for the clips was also substantiated by knowledge gathered from different learning resources, such as textbooks and online encyclopaedias as well as the notes taken by learners in class. This process was conducted over a month with learners uploading clips at their own pace.

5.3 School Background

Like school B in section 4.3, school E is located in a township. Townships are low-income areas whose schools are often challenged by a lack of resources, including an appropriate number of classrooms, teachers skilled in subjects such as science and mathematics, and an adequate number of text books available to each learner. However, unlike school B, this school gave learners access to computers and offered computer lessons but even these computers were not available for learners to use for research or for homework. The school had an average ratio of 35 learners per teacher. Learners in this school also came from low-income families. The learners faced the same challenges as learners in the study presented in chapter 4, having limited access to further resources, such as Internet access and a sufficient number of text books to enhance their learning process.

5.4 The system design process

The methodology used to design the multilingual learning system presented in this chapter is based on the waterfall model described in detail in section 2.2 discussion of methodology. The M-Thuto system in this chapter was a further enhancement of the system presented in the previous chapter to provide an uploading and retrieval

portal for the multilingual mobile audio clips. The model development process followed the same process as the one detailed in section 4.4 using the following basic approach which was derived from the waterfall model: Gathering requirements, analysing the requirements, designing and developing the system, testing and implementation.

5.4.1 Gathering requirements

The requirement gathering process followed the following basic procedure for system design reflected in detail below: establishing the learning objective; establishing current teaching practice and the process of learning in informal environments; establishing how to support the current practice through mobile learning. After consulting with the teacher on how they conduct lessons we established the following.

- **Establish objective**

The teacher's objective was to support learners in their informal learning process by helping them to understand and reflect what they had learnt in class.

- **Establish the current practice**

The teacher provides learners with exercises that test their understanding based on what they had been taught. The teacher also tasks learners to explore new topics using different sources which include their workbooks, before the next lesson. The teacher provides the learners with these tasks verbally code-switching between English and Setswana, Sotho and Sepedi. Content is however presented in English in written format. Learners answer the questions and tasks in their informal environments by reflecting on what they had learnt in class using their own language while providing written responses in English.

- **Establish new support process**

Develop a multilingual mobile learning system that supports the teaching and learning objectives for informal learning by using current practice that will also inform a proposed framework.

In the current practice of informal teaching and learning, the teacher provides learners with exercises or task based approaches that learners answer as a way of reflecting upon what they had been taught. The teacher provides learners with notes that they will reflect upon with the aim of understanding what they had been taught during their lesson. The teacher may also ask learners to research a topic that they will cover in lessons to come.

Similar to chapter 4, current classroom teaching and learning involves the use of two or more languages. The teacher switches between the two or more languages while teaching and providing learners with notes. In the informal learning process, even though the learners were expected to document their work using one language, the learners could use more than one language to interpret the content. The objective requirement of the proposed mobile learning system was to support the current multilingual mobile learning process in an informal learning environment. The system objective was mainly to support the learners in their learning process while allowing the teacher to monitor the informal learning process.

5.4.2 Analysing the requirements

The analysis of the system requirements revealed four essential issues:

- More than one language was used both for teaching and learning with the switch occurring more frequently in the informal environments;
- As it is often difficult to engage learners in informal learning the teacher often sought engaging approaches to enable them to learn outside the classroom;

- In informal environments, learners were required to reflect on what they had learnt in class in their formal learning, and to discover new knowledge;
- Challenge - the teacher did not currently use technology as part of their teaching process;
- Challenge - the teacher had no skills of using an authoring system.

These perspectives affected the design process and had to be embedded into the design process. As with the previous schools which used the same groups of languages to communicate, the use of languages in this area gave us the opportunity to narrow the languages down to those most common to the process of learning and teaching; those mainly influenced by the geographic location of the school. No technology was currently being used to support the learner's informal learning, therefore both the learners and teacher had minimal experience of learning supported by electronic devices.

5.4.3 Designing and developing the system

Pedagogical design

The pedagogical perspective design was based on the current practice of informal learning. The teacher gave the learners the common task of reflecting on what they had learnt, this time with the support of a mobile learning system. The learners were thus required to use their usual sources of learning to support the search for additional information. After these reflections, the learners were then to use the mobile phones to create audio clips that they would upload onto the system. These clips would be kept for their own revision purposes and for use by their teacher to monitor their understanding.

Every content view page was presented using two languages, narrowed down to English and Setswana. Setswana forms part of the Sotho group of languages, which includes Setswana, Sotho and Sepedi.

The learning process, in which the teachers designed informal learning tasks, was mainly based on a constructivist approach. As reflected in section 3.12, in a constructivist learning environment, the learners are given the opportunity to create and reflect upon knowledge as part of the learning process. The learners may use different resources to explore the learning process, which include text books, their class notes, the knowledge they had acquired during lessons, and other online and offline sources. Constructivism also makes allowance for collaboration with fellow learners. Learning becomes a process of a conversation between the learner and their context, with the outcome a matter of personal reflection based upon the interpretation and understanding of the learner (Sharples, 2000) .

Architectural design

The system was based on the architecture described in detail in section 2.4.3. The system designed in this chapter was based on the same architecture approach as the system described in chapter 4. After analysing both the teacher's objectives for the learners' informal learning and the challenges posed by the system, the second phase of the M-Thuto system was designed.

The system interface

The system interface was designed to attract young high school learners. The usability principles provided by Kukulska-Hulme and Traxler (2005) were taken into account as the principal considerations for the interface design of the mobile learning system. *The size of screen* – there is a limit on the amount of information that can be placed on the mobile screen. *The keypad* – it is important to design a system that will require minimal keypad use.

Other interface design issues were considered, notably the design of the navigation buttons that enabled learner to move back and forth between the pages of the system.

5.4.4 Testing and implementation

The testing stage involved a pilot study with high school learners from local schools. The learners were randomly selected based on their agreement to participate in the research after a request was sent for voluntary participation for the pilot study. The same pilot process was followed as the one described in section 2.3. In the testing phase, all participants used their own mobile phones. The learners gave feedback about the system, once again citing the need for more animated graphics as their main concern. The results of the testing stage through a pilot study were used to improve the system. The final system used to support the learning process is illustrated in Figure 5.1 below.

The system

Each learner had a system profile which they used to log onto the system. Learning records were stored under each individual learner's profile. The system included a menu that allowed each learner to choose their subject area. In view of the constraints of time and the financial resources allocated to this research process, only the science option was developed and available for learners to select. After a learner had accessed the science page, the system gave her the option to view the different learning topics covered in the subject area. The learner then had to select the topic under which they would like to upload their audio notes. The notes were stored categorically based on the subject topic and upload date. The learner would then have an option to later listen to the notes they had stored. The system also allowed the teacher to view and listen to all of learners' notes. The following diagram illustrates the system.



Please enter your login details below:

Name/Igama/Leina

School/Isikole/Sekolo



Click on your choice of subject
/Tlhopa serutwa se o eletsang go se ithuta

- [Mathematics/Dipalo](#)
- Science
- English/Sekgoa
- Biology/Dirutwa tsa Maphelo
- Computer Studies/Dirutwa tsa setegniki

[logout](#)

Physical science subject/ Tsa science

1. Vectors / Di Vector
2. Newton's law/ Molao wa ga Newton
3. Atomic combinations/ Kopano ya diatom
4. Electrical circuits/ Di Circuit tsa motlakase

[Click here to view more options / tobetsa fa go bona tse dingwe <> Go back/ Boela morago](#)

1. The system provides a login portal where each learner is able to access her profile.

2. After logging in, the learners are given an option to choose the subject in which they want to learn.

3. After choosing their subject area learners would choose the topic that they were currently learning in class.

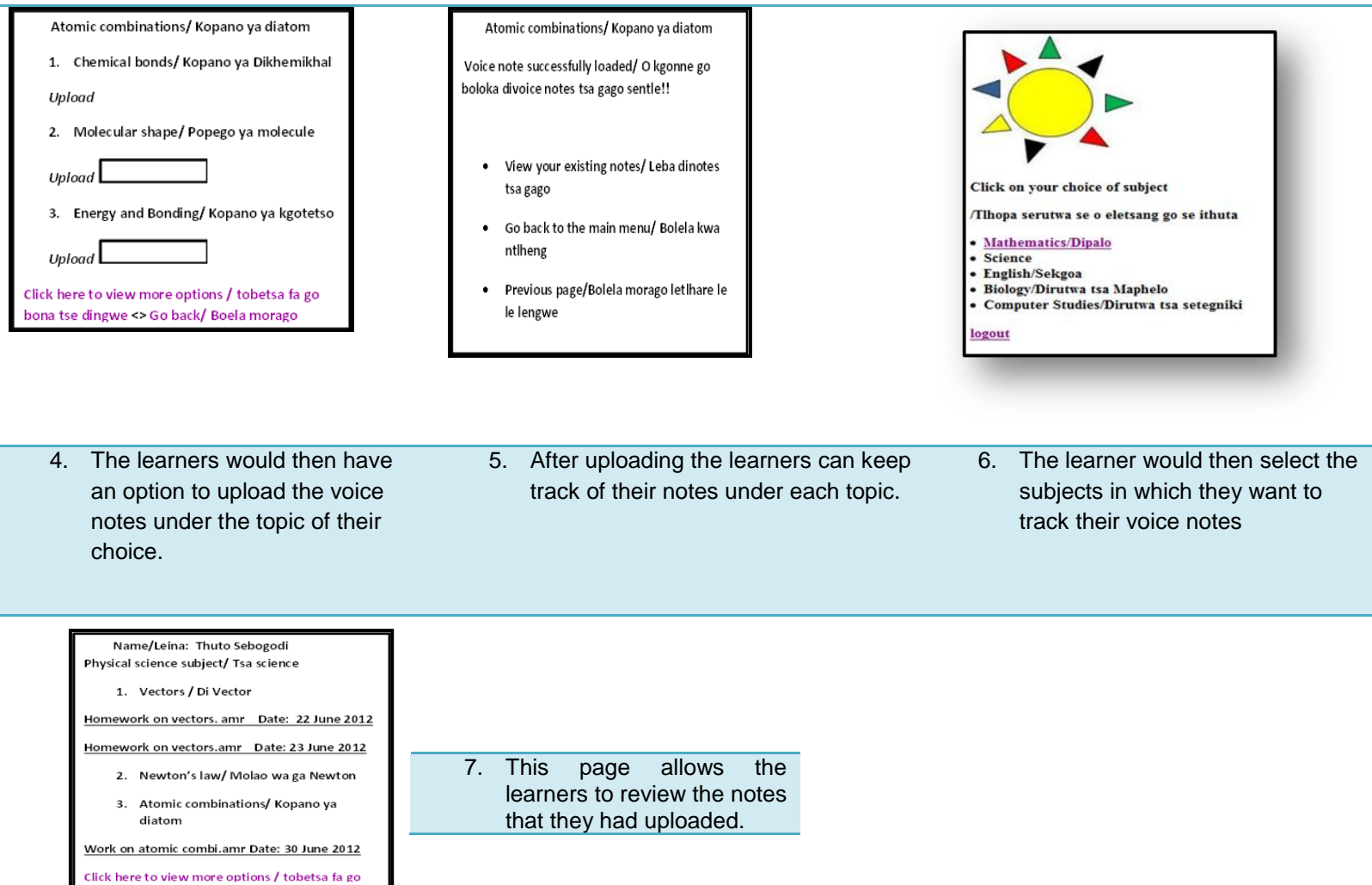


Figure 5. 1 The informal learning process M-Thuto system

5.5 Data analysis methodology and presentation

After learners created clips and uploaded them for a period of a month, four learners were interviewed through semi-structured interviews subsequent to the study. The choice for using semi-structured interviews which is detailed in section 2.2 was motivated by their flexibility in providing a formal guideline of questions while giving respondents an opportunity to expand on their views. The remaining learners filled in questionnaires. The system also kept a record of how many times audio clips were uploaded. The audio clips also provided valuable information that allowed us to monitor the type of content learners created against what they had been taught already in class. Under each theme where individual participant's views were quoted, the views expressed by the participants emphasize their own views and not of the collective unless otherwise stated.

The data collected was then to be analysed thematically as follows.

Linguistic, financial and technology background of learners

This theme sought to establish data in the following categories:

- Linguistic – determining the linguistic background of each participant, establishing which languages they could read, write and use for learning, and also determining how code-switching was used to support learning;
- Financial - whether the learners could afford to purchase learning resources such as additional books to support the learning process;
- Technology background – establishing whether the learners had frequent access to electronic resources to support learning.

Learning resources, content and learning activities

This theme investigated how learners currently use learning resources in informal learning spaces (books, computers or mobile phones) to support the process of learning. It also aimed to establish how language is used in the informal learning process, taking into account information regarding how the teacher creates current learning material and activities using multiple languages.

The interaction with the M-Thuto system

This theme investigated the manner in which the learners used the M-Thuto system to support their learning process. The theme reflected on the learners' interaction with the system, monitoring their frequency of use, their perspectives on the usability of the system and their use of multiple languages in the learning process.

5.6 Data analysis of the main study

5.6.1 The financial, linguistic and technology background of learners

Financial issues

The results of this study reflected the financial challenges that participants faced, such as being unable to afford additional costs related to education (purchasing additional books and obtaining other sources of learning). These learners came from the area surrounding the school which is a predominantly low-income. Learners relied solely on the reading and learning material that they received in school.

Even though these learners could not access further resources, the participants spoke about their willingness to share resources. If any other learner had access to

an essential book (other than the books provided in school), the learners would share this resource amongst each other. When asked if they had access to computers (as reflected in appendix B question 15), a majority of 80% of the participating learners had no access to personal computers, which meant that they had no access to situated electronic learning devices. However, the school offered the use of on-site computers and computer lessons were proposed as an optional subject for the learners. We might also bear in mind that these computers did not provide Internet access and that they were reserved for learners who were registered for the computing course.

Language

All of the participating learners were either second or third language English speakers. All of the learners communicated the fact that their teachers frequently used different languages in class to code-switch and explain concepts. We also noted that while the teachers code-switched, only one language was used for formal writing, which was the English language. The first languages of the learners participating in the study ranged between Setswana, Sepedi, Sesotho and Ndebele. The Sepedi language dominated as the mother tongue common to all the participants. The most commonly spoken languages used in this school belonged to the Sotho family of languages. The use of this group of languages during the interviews made communication easier with the learners as we were able to code-switch between these languages and the English language.

It was also interesting to note from the questionnaires that according to the learners the teacher's code-switching practice varied with languages, although the change occurred between languages which belonged to the same Sotho language group, reflected in Figure 5.2. In interviews with the teacher, it became clear that code-switching occurred more frequently when they introduced topics to learners or

reaffirmed what they had taught them. The teacher stated that: “If I see them not understanding what I have taught, mostly based on the questions they ask me or based on the responses I get when I ask them questions, I often code-switch to explain again.”

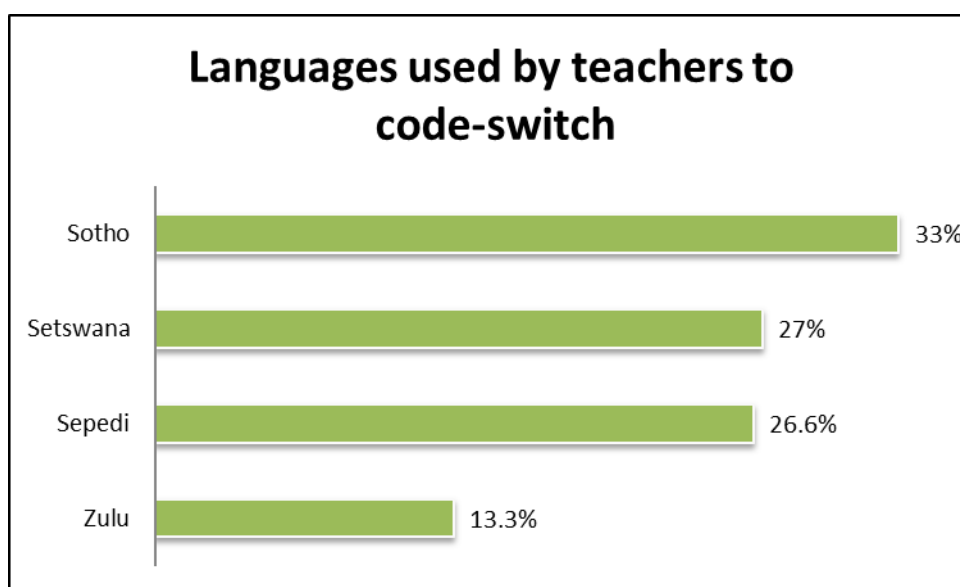


Figure 5. 2 The percentage of languages according to learners that were used by the teacher when code-switching between English during lessons

In informal learning all learners reflected their frequent switch between languages to interpret their learning content. This was especially the case in subjects which they considered challenging such as science and mathematics. The learners reflected that when learning with fellow learners in informal learning environments they used more of their native languages to communicate and learn with each other. English was formally used more frequently in classroom learning.

Technology

From the data presented, when investigating the ownership of mobile phones (in appendix B, question 17 and 19), it is clear that there was a low ownership of mobile phones in this school, with only 33% of learners owning a mobile phone and 27% of these mobile devices having WAP features. However, all the participating learners

had access to mobile phones at home, reflecting the potential of mobile phones to provide support, especially in informal learning. Even if the learners are not able to access the mobile phones from school, they had access to them from home.

It is also important to note that even though ownership of mobile phones was low amongst participants, learners did not struggle to use the mobile phones with which they were provided for the purposes of the research project. Therefore, the learners had no experience of using the model of mobile phones provided. Nonetheless, 73% of the learners found the process of creating sound clip from the installed feature (in appendix B, question 30) to be very simple on the model provided. We can thus conclude that the great majority of learners had no real problem using the devices in their learning process despite lacking personal ownership of mobile devices.

All the learners mentioned that they were, at times, expected to do their homework with information obtained through online research in spite of the fact that they had no access to computers. Although the sample size was small, the results reflect the challenges of accessing electronic learning platforms for learners in low-income areas to support informal learning.

5.6.2 Learning resources, content and learning activities

Having been tasked with creating their own audio notes from different learning sources, the learner's interaction with the M-Thuto system was monitored to determine how effective its use would be in their learning process.

Upon completion of the interaction process, the learners were questioned about the informal spaces in which they learned most frequently. Most of these learners stated that their informal learning occurred at home, in school after lessons and at the library. The learning sources from which the learners got access to learning material in their informal learning environment included: their current text-books, their class

notes and other rarely cited sources such as commercial newspapers (sometimes providing relevant information and working examples of their current objects of study), copies of past examination papers obtained from fellow students, and supplementary study workbooks which could be purchased.

After each lesson, the learners would use these resources in their informal environments to either answer questions from their workbook intended to make them reflect on the day's lessons, or perform a task set by the teacher requiring them to reflect on what they had been taught in order to gain a clearer understanding. These learning activities included responding to questions set by the teacher. At other times, learners would be expected to work together on a task.

The learners were also asked how often they revised school-work when they were not otherwise presented with learning activities.

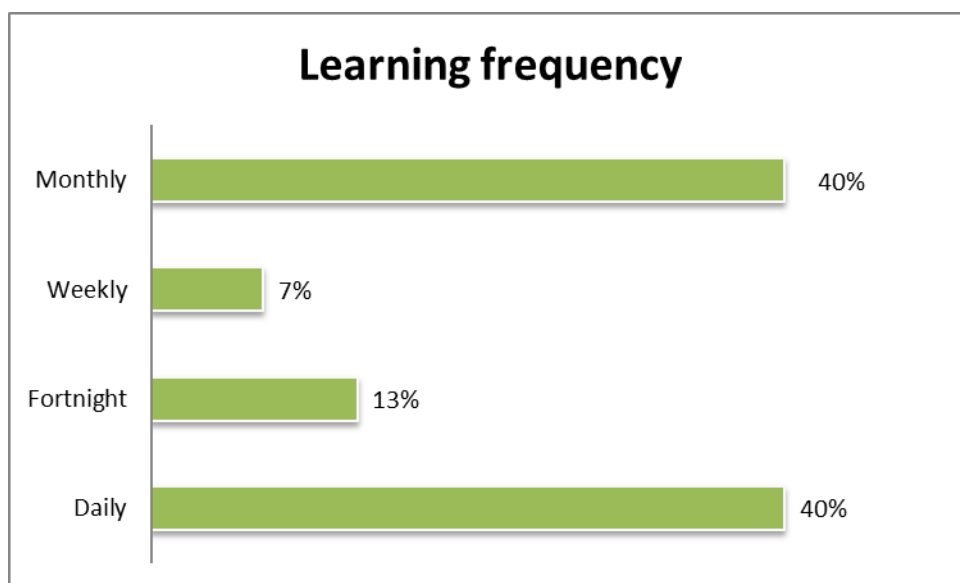


Figure 5. 3 The percentage frequency of learners' school work revision

In figure 5.3, most of the participants revised when asked about their frequency of learning (in appendix B, question 27) 40% of learners revising daily and 40%

monthly, while the other 13% of learners revised on a fortnightly basis leaving 7% who revised on a weekly basis.

The participants were also asked about how they used languages for learning. All the learners acknowledged using different languages both to interpret and to explain the content to themselves, to each other and to their teacher while learning. However, there was one clear language of formally documenting and receiving learning content, which was English.

5.6.3 The interaction with the M-Thuto system

An evaluation of the learners' interaction with the system was conducted in order to monitor the support that mobile learning could give to informal multilingual learning. The first step in this process was to establish if the support provided by the mobile device had motivated a higher learning frequency. There were issues to be considered such as learners being initially excited by the new objects and only later seeing electronic devices as a learning tool by which time they had lost interest in the concept of technology-supported learning. However, it was interesting to note clear and positive changes in learning patterns through the use of the mobile phone. The interaction monitoring process also focused upon the use of language in the following areas: the participants' mobile learning process, the learning process itself, and the usability and efficiency of the devices as a learning support.

Language support

In creating the requested sound clips when asked which languages the learners used (in appendix B, question 33), only 20% of the learners used solely the English language to create their notes. The Sepedi language was the other dominant language, with 58% of the learners using it alongside English to create audio notes. Only two other languages were used: Setswana at 33% and Sotho at 8%. In reality,

the participating school is located in a largely Sepedi-speaking area which proved the strongest influence on the language selected by the learners.

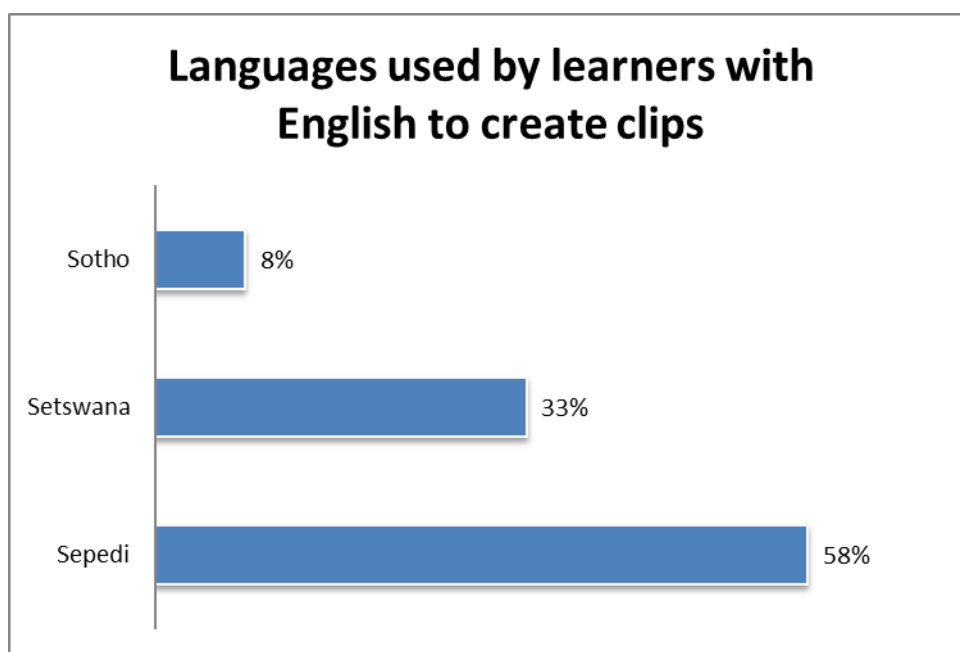


Figure 5. 4 The languages used to create the audio clips

Figure 5.4, illustrates the percentages of languages used and also once again, the same pattern of using a single family of languages which included Sepedi, Setswana and Sotho was reflected in the languages used to create the audio clips. Switching between English and these three languages while creating the clips, the learners drew upon the same family of languages that the teachers used during lessons.

The learning process

The creation of personal notes for learners shifted the responsibility from the teacher to the learner so allowing learners to create their own learning environment. Although the learners had at times been provided with learning tasks that required

them to be responsible for their own knowledge acquisition, this was their first experience of using mobile technology in that process.

The notes designed by the learners were very comprehensive. The learners created them as a formal audio presentation of their reflections on what they had learned, even if they were learning in a more relaxed environment. It was also interesting to note that some learners worked together to create notes based on a topic they had learnt during the day in school.

Through the use of mobile phones, learners had access to a personal environment that allowed them to truly express their understanding of the topic area. Listening to the learners' audio notes, you can hear that they were relaxed when creating them. At times they would even mention that they did not understand what the teacher meant in a particular study area. Learner A states in one of the recordings: " Mam to be honest on the issue of electrodes, I was not clear what you meant on this issue....". Giving their views on the audio notes, the learners expressed the feeling that they could relate well to their personal notes and were subsequently open to admitting where they did not understand. It was also interesting to note how they were able to critique their own understanding when reflecting back on their own recordings.

Learner B mentioned the benefit of re-recording to the process of creating the recorded notes because it allowed her another chance to express her ideas whenever she felt that what she was saying did not make sense.

There were also various complaints from learners regarding the slow pace of uploading and downloading their voice clips. This reflected the challenges of accessing Internet connection as they were accessing it from various locations.

The teacher in this class felt that, “It is helpful for me to access the audio clips of the learners. The learners are free when making them, which helps me realise the challenges that they might not be able to talk about during class.”

Frequency of use

The participating learners were questioned (in appendix B, question 37) on their frequency of revising what they had been taught during their lessons using their created clips through the support of the mobile learning system. There was now an increase in the number of learners who were learning on a daily and a weekly basis. All learners fell into the categories of learning frequencies outlined in Figure 5.5. It is also important to note that learners may lose the motivation to use technology if it becomes an essential part of the learning process.

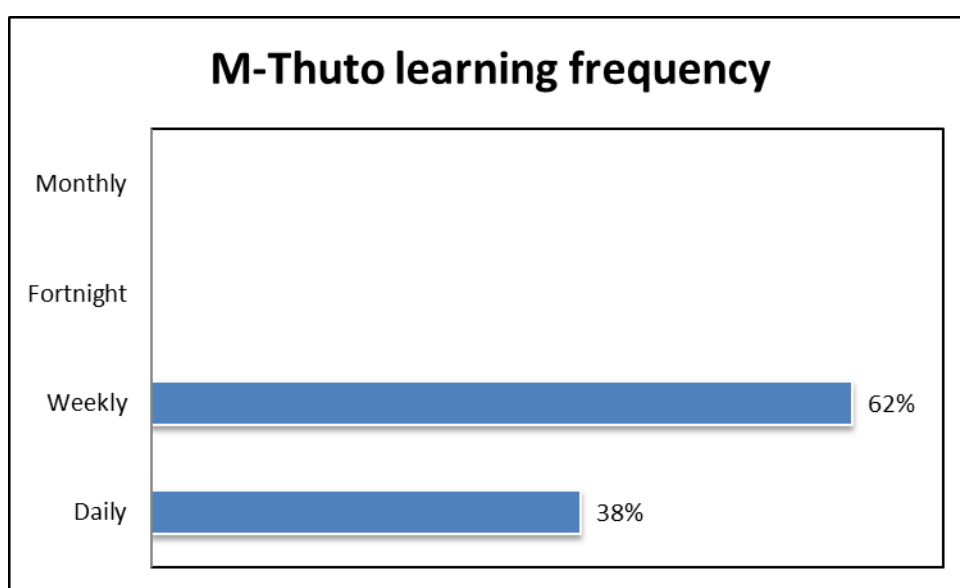


Figure 5. 5 The frequency of learning during the use of the M-Thuto system

Most learners were creating the clips on a daily and weekly base with no learners creating clips at later intervals.

5.6.4 Usability aspects and effective support for learning

The usability of the system played an important role in learner interaction with the system. The learners were asked about the process of learning on a mobile phone and through the system designed for them. The learners were primarily more concerned about the look and feel of the system than the ease of use.

Of the participating learners, when asked about their preference of study platform (in appendix B, question 38), 53% preferred using both the text-book and their audio clips for learning, while the remaining learners preferred the traditional method of learning from their text-books. Student I, felt that, “It is difficult to focus on learning on the phone and it’s easier in a book because a phone has many distractions”. On the other hand, Student K’s reflection was that, “I found it easier to listen to myself and make sense of what I was saying. I think my personal notes are easier to understand than the ones in the book”. While learning could be supported through mobile devices, other learners feared that the mobile phone was also a potential distraction in their learning process. There was thus a motivation to use dedicated mobile learning devices which regulate what the learner can do during the learning process.

One of the learners also touched upon an interesting point:” Textbooks have all the information that I need in one central place.” It seemed that searching for information and learning material on the mobile Internet was a tedious process. Instead, learning material supplied to learners through mobile online sources should be located in a single, central location as learners are often reluctant to look for what they need. Reflecting upon the interview process, we realised that even though mobile devices are able to provide electronic support, the learning foundations for new concepts can be provided through other sources because the limited screen sizes presents limits to what the devices can initially present to learners.

5.7 Discussion

In this chapter we aimed to answer the following research question:

Question 2: How can mobile learning be used to support multilingual learners in their informal learning process?

The financial challenges faced by the participating learners, in particular their inability to afford the necessary learning materials, reflects the need for affordable learning resources based on the tools to which learners already have access and which will ensure the sustainability of any initiative. Taking advantage of the wide access of mobile phones in South Africa and the access that all participants had at home, mobile phones have become the main devices for supporting the mobile learning process. Mobile devices or in this case mobile phones are able to provide the central learning resources that can be used even in informal environments as learners have more access to them in their home environments.

Language forms an important role in the design of such a system, as both learners and their teachers constantly code-switch in the learning process. Knowledge of the languages used within a learning area and the culture in which they are used in their informal learning facilitates the selection of an appropriate design which will provide support based on how the languages are used for teaching and learning. This study observed that language in informal learning language was used by learners to interpret content, while teachers in the formal classroom used it either to introduce content or reaffirm what they had taught. It is also important to note that while there may be multiple languages for learning, one specific language must be used to respond to content. In informal environments there was a need to provide flexible mobile learning systems as code-switching occurred much more frequently as the learners commonly relied on their home languages for learning. Mobile systems can be modelled to present flexibility of language use in informal learning through audio

storage portals such as the one presented in this study and through dedicated learning chatrooms.

The design process of the software was influenced by the teacher. This is an important aspect of technology design for education use because the teacher drives the educational approach within the classroom. In the study, the teacher was also able to guide us in regard to the behaviour of learners in the informal learning environment. Developing a system related to the current practice of informal learning ensures seamless learning, as both teachers and learners are able to adopt it to their current practice. The teacher should also be provided with optimal access to the system. In this study the teacher was able to monitor their own teaching progress and their learner's performance outside of the formal learning environment.

Despite the success of the mobile learning system, learners still highlighted the need for additional support from traditional learning sources such as books as well as their teacher's daily lessons. It was important to note that while mobile learning provides an ubiquitous resource, it had limits on how much learning content and activities could be supported through it to effect an optimal and effective learning process. It was seen by learners as an additional support tool as opposed to a primary learning tool. Such a conclusion illustrates that primary learning concepts should be provided beforehand to learners, drawing on other learning sources. Learners' use of mobile learning tool should not be exclusive of traditional learning resources which should be provided to support the learning process.

The interaction process of the participating learners with the system reflected how, with appropriate learning activities, multilingual learners can be supported through mobile learning. Despite experienced challenges, the study presented in this chapter, mobile learning was able to support learning by acting as a content access

environment and learning activity support using software that supports learning activities in an informal environment.

5.8 Summary

The research presented in this chapter presented the following issues which need to be considered when providing mobile learning support in multilingual informal learning environments: Learners in multilingual context code-switch frequently and so require unrestricted support of their code-switching practice; The learning activities provided through mobile learning devices should be designed to support their consistent switching nature. This chapter also reflected the challenges that come with mobile learning which requires the consistent use of the Internet as some learners struggled with the slow pace of the Internet to upload and access their clips. Mobile devices also present a limit on the extent to which they can support learning. Learners may also prefer the use of other learning sources to support their learning process. These problems can be overcome through reference to preliminary teaching and the use of other learning resources which will have equipped the learner with an essential grounding for learning. Hence, learners would not have to rely on the mobile device as their main source of learning.

The next chapter presents a secondary case study of language support systems that enable multilingual users to access multilingual content. The chapter further evaluates how machine translation features can be used to support mobile learning systems by providing translation support for monolingual mobile learning software developers. We examine through secondary case studies how existing technologies in South Africa have been able to support the development of multilingual content and how we could extend these features to mobile learning in order to support code-switching. Lessons taken from these projects will be employed later in this thesis to contribute towards a multilingual mobile learning framework presented in chapter 8.

Chapter 6

Supporting mobile learning through natural human language processing technology

This chapter presents a secondary case study of technology that has been used in South Africa to support multilingual students. Using some of the eleven official languages of South Africa, it presents two principal approaches: basic natural language support systems and machine translation which can be used to support multilingual content development. These techniques are used to enable users of different languages to access content which is only previously available in English. These approaches will be shown to be useful in contributing to the support that can be provided for multilingual mobile learning development.

6.1 Introduction

In this research we made an active search of existing multilingual mobile learning research initiatives. We found that machine translation and related research was one of the few forms of multilingual user technology most able to provide multilingual technology users with access to content from one language to another.

Limited research already exists offering support for these technologies in African languages. CText is one of the few institutions based in Africa which solely concentrates on enabling multilingual South African users to access multilingual content. They have done extensive work on making resources that were only accessible in English available to users with other South African languages.

In this section we present the support techniques created by the CText for natural human language which they have used to support their online students. We also evaluate other machine translation initiatives provided by the centre. The results

from the case studies will be evaluated through a qualitative process of analysing how the systems are created and how the natural language support techniques can be used to support the mobile learning environment.

In relation to machine translation, as the field of human language translation was not the thesis focus area, we provided a brief view on how it can be used to support multilingual mobile learning content development as there are limited studies providing support on availing multilingual mobile content.

6.2 Using a web-based translator to support multilingual students

In this section we present a secondary analysis of the Centre for Text Technology system by examining their online website portal and other research provided by the centre (Van Huyssteen *et al.*, 2007). The research does not provide the results of user interactions nor does it provide the perspectives of student users on the system's ability to support their multilingual learning process. However, the research does take account of software development techniques which we propose can be used to support future developments in multilingual content support for the code-switching process needed for learning.

As previously mentioned, learners who code-switch can at times struggle to interpret a word presented within a sentence. Here, the learner requires that a translation of the word be presented instantly by the system without having to leave the current reading view. One of the most important ways through which students from the multilingual university of North West are supported in their access to multilingual online content via their university portal is through the basic use of scripting programming languages.

Content on their university website is mainly available in three languages; namely, English, Setswana and Afrikaans. While browsing the university website, students are able to select a word presented in language A and view its alternative in language B by clicking that specific word. This processing of the natural language follows a similar approach to that of machine translation. A database is created of the equivalents of each and every word in a second language. The client or system user thus selects a word and a request is sent to the database to retrieve an alternative to display the word in another language.

6.3 Developing the multilingual language support layer of the system

In this section we describe and analyse how the translation support for the online pages was developed. This process can further be used in online learning sites or systems to support the multilingual learning processes.

6.3.1 Developing the language repository

A linguistic specialist is required at the beginning of the systems development process to obtain the equivalent of every word that can be presented for translation in a user request. The language specialist will be able to provide more than one alternative word in a second language, which will then be presented to the user upon the completion of a word request. Moreover, a source list is created where each word equivalent is stored. The source list is then stored in different language files which will be accessed when the users require a translation. In this case, the English language was the primary language, while Setswana and Afrikaans became the alternative languages requested from the word repository.

Developing the source list is often easier when a specific data domain is restricted to words used within that domain. For example, domain words commonly used in

education or those used in a particular subject. The use of such a system makes the operation easier for the language specialist by allowing them to create a domain specific source list.

6.3.2 Retrieving the words

A database is then developed with parallel text files which enable equivalent words to be sought in the system. When a user places a request, the following search process presented in Figure 6.1 occurs. The user request is initiated with a request for Language P which is the primary language in which the web content is presented. The system then retrieves each file containing both Language P and the equivalent words in the requested language. Finally, the system either returns the word or returns a null value.

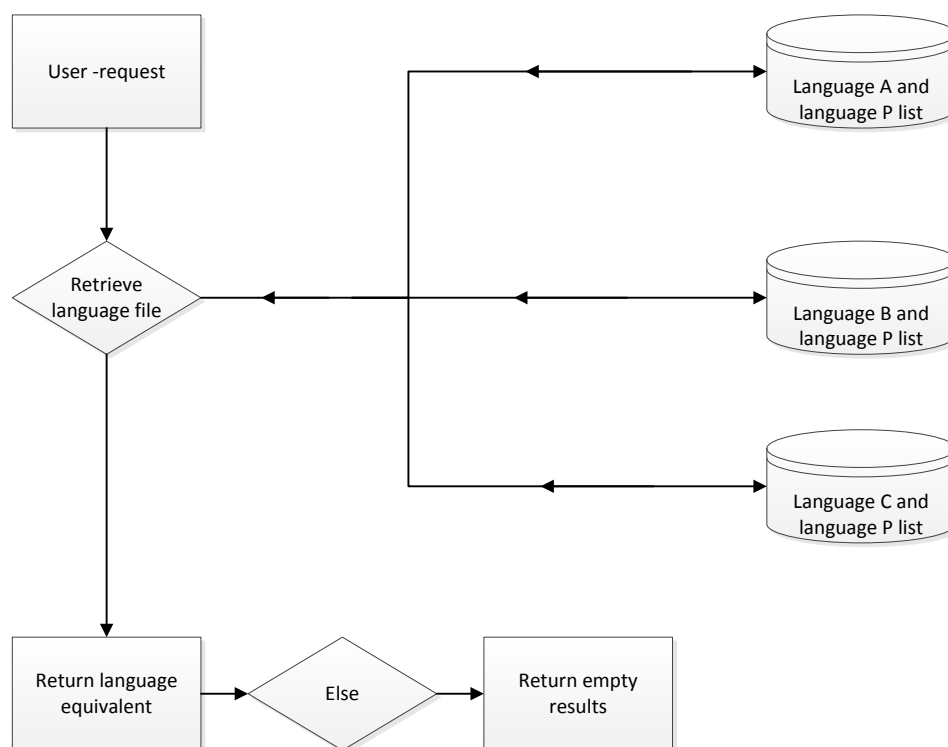


Figure 6. 1 Searching for a word equal

Through a basic PHP command, the system searches the database to retrieve the source list files. For the purposes of this command example the language files are

named WordLangP for the primary language words, while the users seek the equivalent words in WordLangC files.

Through a scripting command, the system retrieves and displays the words alternatives. This basic command can also be used to support online mobile and electronic learning content. An example taken where equivalent words come up as positive results is presented in Figure 6.2 .



Figure 6. 2 Returning alternative words (Van Huyssteen *et al.*, 2007)

This box displays the alternative words
to the word *know* in Afrikaans

6.3.3 System analysis

A description of the system outline above does not supply us with adequate analysis of the quality of alternative words provided. Nonetheless, its benefit is that it facilitates the plug-and-play concept of supporting multilingual mobile learning. Programmers in the CText use a basic scripting language such as Java Script to facilitate this process. Such a programming language allows the coding to be embedded into any mobile learning system as an additional support to the content presented for learning. It can provide learners with the ability to search for an alternative word within the same page view given by the mobile device.

The challenge in creating a similar system to support the mobile learning process is dealing with the initial translation requirement. The system requires the expertise of a language specialist to meet the challenge of a translation between languages with different morphological structures. However the translation process is a one-off process which can be updated when new words are contributed to a pre-defined source list as displayed above. The words will then be stored in a source list that can be imported and shared with other multilingual mobile learning systems. The centre has already created a list of source words for different South African languages, although this list was created specifically for government use across the public domain. A new list can be created more suitable for the South African education system, updating it with jargon familiar to different learning areas. In the next section we consider how we can support translating content when creating a multilingual mobile learning system where there are no human language specialists to support the translation process.

6.4 Using machine translation to support multilingual content

For the purposes of this thesis, we describe machine translation as one of the processes which can be used to support the translation of content when human

language specialists are a scarce resource to facilitate the process. This section investigates alternative methods that mobile learning developers can use to translate content from one language to another in the absence or scarce availability of a language specialist to aid the process of multilingual content development.

We noted in Chapter 4 that all learning content created for the M-Thuto system has been translated by language specialists from English to Setswana. In instances where human translators are not so accessible, machine translation provides an alternative for creating multilingual learning content.

The process of translating human language has been in practice for some time. However, with the increasing need to translate content to enable different language speakers to access knowledge, the need for electronic translators has increased in recent years. Although technology-based translation is not as accurate as a human translator, there has been a great improvement in the design of recent translation technology. For this research project we aimed to establish how technology can be used to support multilingual mobile learning. In South African schools much learning content is already available in English. For the purposes of this research we consider how translation can be effective in circumstances where there are no human translators to support translation from English to any one of the other ten South African languages. We investigate a case study in which the CText developed a translation mechanism for translating content from English to Setswana.

The Bantu languages of South Africa are divided into different language groups which also constitute ethnic groups, entailing that speakers of languages belonging to the same group are easily able to communicate with each other (SouthAfricanInfo, 2012) . For example the Sotho group contains Setswana, Sotho and Sepedi. Speakers of any of these three languages can easily communicate with

each other. We also noted in Chapter 5, Section 5.6.3 that speakers of the same language group tend to code-switch within the same group of languages. We saw that the teacher participating in the study conducted in Chapter 5, code-switched between English and other languages in the Sotho group during lessons. A similar process took place when the learners of Chapter 5 created audio clips by code-switching through English and other language members of the Sotho family of languages.

Figure 6.3 displays the existing different language groups in South Africa. It is important to note that the Xitsonga, TshiVenda, the Afrikaans and the English languages are not immediately related to other groups of languages. One might also take into account that, following a deeper lexical analysis, these languages may display similarities.

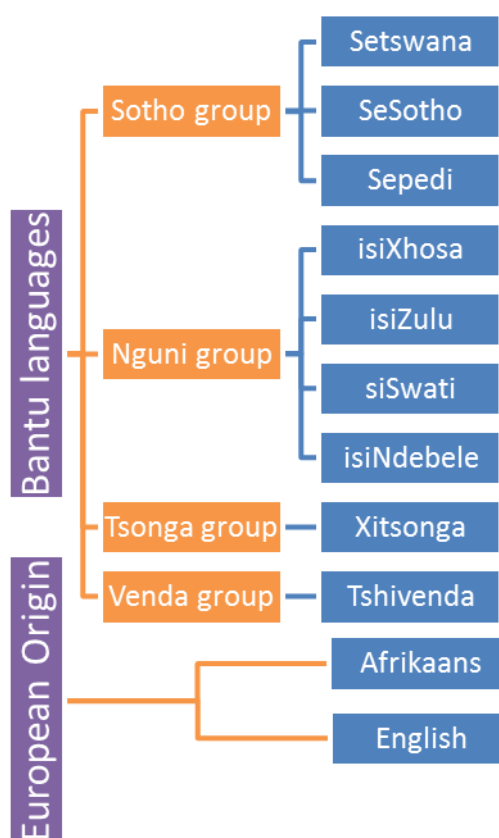


Figure 6. 3 The South African language groups (PanSALB, 1999)

The translation of English content to another language belonging to the said group of South African languages can thus assist other speakers in the same group to access learning information.

6.5 Different types of machine translation methods

Machine translation can be described as a machine-aided process where content is translated from one language to another. This process can occur without constant human intervention as the system converts content unaided with a predefined source as reflected in the previous example. As mentioned in section 3.8 of literature, there are different types of machine language translation methods which include rule-based translations, statistical and hybrid translation approaches (Yamada and Knight, 2001; Van Huyssteen and Pilon 2009). In this section we will evaluate two case studies of machine translation which makes use of rule based approaches. These case studies were selected based on the limited availability of studies that reflect the translation between English and other South African languages.

6.6 Case study methodology

In this chapter, two case studies are evaluated involving different machine translation approaches used to support the translation of content from Dutch to Afrikaans and from English to Setswana. We chose the Dutch-to-Afrikaans translation case study as it provided one of the few examples of where Dutch (using a significant number of published resources) is translated into a South African language through the exclusive utilization of a rule system.

The second case study was chosen because it is the only case which depicts the translation of English to Setswana. Setswana also belongs to the group of Sotho languages. The advantage of translating content into this group of languages also means that Sepedi and Sesotho learners can access the learning material in their own languages. The techniques described in this chapter can be used to support the development of a mobile learning system that enables learning content to be accessible in both English and other South African languages. In the two case studies, we look at the translation techniques and outline the best approach adopted to support the development of mobile learning content.

Translation can take place using both manual and electronic systems. Machine translation systems are openly available systems which just require the definition of a set of rules to enable the process to occur. In this chapter we will focus on the automated process which nonetheless requires some form of manual support.

6.7 Using the rule-based system for similar languages - a case study based on the findings of Van Huyssteen and Pilon (2009)

In this case study, rules are defined for use in the support of translation through an automated system. Here, the rule-based conversion established by Van Huyssteen and Pilon (2009) reflects the lexical similarities that exist between Dutch and Afrikaans.

Although Afrikaans was originally considered to be a dialect of the Dutch language it evolved towards having the status of a language. The Dutch and Afrikaans languages thus have a relationship on the morphological level (in their shared grammar structure); and on the lexical level. If we take the orthographic level (for example, in the phonology, the spelling and the pronunciation of the languages), we

see that the languages appear to display clear differences in spelling and word ordering, but the number of similarities between the languages on other levels provides solid grounds for the translation process to occur. The existing similarities thus allow rules to be defined based on the connecting properties.

In their system design process Van Huyssteen and Pilon (2009) suggest a modular design approach which enables non-programming specialists to interact with the system. The design of the translation convertor consists of two main modules: the Dutch-to-Afrikaans lexical level (D2Alex) and the Afrikaans lexical level (AfrLex).

The translator initially accepts the Dutch version of the words to be translated, which are then placed in the relevant list (List.D2AC.Ndl.txt). The inputs for this study exclude the incorrect spellings of words, abbreviated words, acronyms and formal names, such as people and place names. After translation has taken place, the translator will produce a converted list (List.D2AC.Afr.txt). The system makes use of four tags which appear in the output list, <<D2Alex>> , signifying the translation of a word as a non-cognate (which means translation of a Dutch word to an Afrikaans word that does not have the same history of origin in its structure or is not rooted in the Dutch word). <<AfrLex>>, contrary to the <<D2Alex>> tag, signifies the translation of a word as an identical cognate (which means the translation of a Dutch word to an Afrikaans word that does have the same origin in its structure or is rooted in the Dutch word). The other two tags are the <<Translated>> , signifying that the translation of a Dutch word to an Afrikaans word has taken place having met language semantic and grammar rules, and the <<Untranslated>> , signifying that there was no justification to translate the word being that it did not meet any of the specified rules.

In conclusion, a language specialist is free to define the rules of this system and so enable the translation by specifying the semantic and grammatical requirements that are to be met before a word is translated.

6.8 Discussion

The Afrikaans language originates from the Dutch language, entailing that a single set of semantic rules presides over the conversion process between the two languages. Although speakers of both languages can easily communicate with each other, the Afrikaans language departs in diverse ways from the grammatical structure of the Dutch language. Consequently, the language rules must support a conversion between the two, taking into account the differences that appear in the grammatical structure of words and how the words precede each other in the language. The authors take an important example of the following sentence written in Dutch: ***Hy het die trein amper gehaald***, which means ‘*He almost did not get the train*’ when translated to English. In Afrikaans the sentence ***Hy het die trein amper gehaal***, means ‘*He almost got on to the train*’. The incidence of this significant difference in meaning hence requires that the rules and the process of ordering words in a sentence be understood if an accurate conversion is to take place between the two languages.

The modular translation of Dutch to Afrikaans uses a significant number of rules to determine which words accord with the semantic and grammatical levels to be considered during conversion if they do not initially display similarities. The conversion thus requires the consistent support of a linguist specialist, one who not only defines the rules of the conversion but also reviews the converted words after the conversion process has taken place. While the system makes a significant contribution towards rule-based conversion between similar languages, the system

also requires a high level of linguistic design support. In environments where there are few translating professionals, the system will become difficult to maintain.

6.9 Using a rule-based system for different languages to enable the machine translation of Wilken *et al.*, (2012)

As previously mentioned in section 3.8, there are many existing machine translation systems and software which only require the definition of rules and corresponding training in their use to enable effective translation. These include open source systems such as Moses (Koehn *et al.*, 2007) where, alongside rule definition and statistical support, only basic commands are required to complete an electronic translation process. In this section we evaluate the system translating the English language to the Setswana language.

In developing the machine translation process used in this case, Wilken *et al.* (2012) initially worked with language specialists to develop rules that would govern the translation process. However, as English and Setswana display different lexical structures, it was difficult to use lexical rules to enable the first step of translation. The data was then first annotated. In this process the English words are placed into linguistic categories i.e. nouns, verbs etc. The words were then placed parallel to equivalent words in a source list to their counterpart words in the Setswana language, as shown in Figure 6.4. There are many resources or modes of software coding that enable English annotation, as it is a widely translated language. Wilken *et al.* (2012) used an automatic speech tagging process already made available by the Stanford PoS Tagger.

Language of instruction English	The	Sun	Rises	In	The	East
Language of translation Setswana	No equivalent	Letsatsi	Tlhaba	Mo teng	No equivalent	Botlhaba

Figure 6.4 Translation from English to Setswana

The process shown in Figure 6.4 was achieved through the deletion, replacement and reordering of words. In the deletion process, for each word which does not exist in Setswana, the word is removed from the sentence. For example, in Figure 6.4 there is no equivalent to the word '*the*'. Conjunction words are common examples of words that do not exist in Setswana but do so in English. The next process was then to replace the conjunction words in Setswana with their possible English equivalent. Finally the sentences in Setswana were reordered as English sentences, as seen in Figure 6.5

Setswana	Nouns	Adjectives/pronouns/cardinals	
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Figure 6. 5 The Setswana sentence ordering process

Wilken *et al.* (2012), describe the importance of defining a determiner rule to enable the identification of a determiner within a sentence if it was not identified in the previous process. Determiners are words that precede each other to explain a noun. They include words such as: the, my, some. These words are not present in the

Setswana language. Once they are identified, they are then removed from the sentences.

Using a Bilingual Evaluation Understudy (BLEU) and National institute of Standards and Technology (NIST) test, 500 translated words forming sentences were passed through this process with the purpose of checking the quality of the output in translation. The authors used data from the government domain for experimental process. For the BLEU score results, the data was first translated by an expert from English to Setswana. A BLEU score is the comparison of translated data between a human translation and an automated machine translation process, where the proximity of the results are evaluated. The range of the BLEU score is from 0 to 1, with 0 entailing that there are no similarities between the text and 1 denoting a high level of similarity between the text (Wilken *et al.*, 2012). These results are expressed in figure 6.6 below

System	BLEU	BLEU %	NIST
Baseline	0.2744	27.44%	6.0911
Extended	0.2880	28.80%	6.1807
		(+1.36%)	
Reordering	0.2781	27.81%	6.1155
		(+0.37%)	
Replacement	0.2751	27.51%	6.1049
		(+0.07%)	
Deletion	0.2813	28.13%	6.1488
		(+0.69%)	
Deletion-Reordering	0.2861	28.61%	6.1444
		(+1.17%)	
Deletion-Replacement	0.2817	28.17%	6.1495
		(+0.73%)	

Figure 6. 6 The results of the BLEU and NIST test (Wiken *et al.*, 2012:6).

While reflecting low results in terms of the quality of translation using the different processes, the BLEU scores nonetheless reflect the significant possibility of translating basic text to provide multilingual support.

6.10 Discussion

The rules defined above provide a basic guideline that can support the process of translating content from English to other South African languages. However, it is crucial that a language specialist always play a role in the translation process. Determining rules, such as the deletion of the determiner in a sentence, can only be performed with the help of a language specialist. An individual who cannot speak a given language will not easily identify a word determiner in said language. Although the presence of a linguistic specialist can be required to define the translation rules of the system, the rule definition is a one-off process which can enable future translations without the need for a translator. However, there is no guarantee implicit to the process that quality data will emerge consistently.

Importing these techniques to support the translation of learning content can make the process of availing multilingual content much easier, especially in environments where translators are a scarce resource. Machine translation has the capacity to support learning software developers by providing an alternative to multilingual content. Ultimately, learning content that has passed through machine translation will be used to provide multilingual views of the content in a mobile learning system.

It should be noted, however, that although machine translation does provide an alternative, it cannot be relied upon as the main process of support as education learning content. It requires accuracy to ensure that learners understand the learning content and the process of machine translation still has a long way to go before it can reach the level of perfection implicit to the process of expert human translation. In proposing the process of machine translation as an alternative from translating content when developing multilingual mobile learning systems, we would still emphasize the condition that it can only be utilized in environments where specialist translators are a scarce resource.

6.11 Summary

In this chapter we evaluated different systems developed by the CText which have been developed to support the translation of content from the English language to South African languages. We established a method which can be used within content to provide multilingual support for mobile learning systems. We then evaluated two case studies that took into account machine translation methods and considered how these methods can be used to support multilingual mobile learning development process as a separate process.

The following chapter describes the method by which we developed the multilingual mobile learning framework proposed for our research in chapter 8.

Chapter 7

The development approach of the proposed framework

Chapter 7 combines the theoretical and empirical findings established in previous chapters to describe the process of how the multilingual mobile learning framework presented in chapter 8 was developed. In Chapter 3, we established the literature background of the research area, and the theories which contribute to supporting multilingual mobile learning. Following this, Chapters 4 and 5 presented two case studies which established: firstly, the characteristics of a mobile learning environment; secondly, the mobile learning process in supporting learning within a multilingual environment; and thirdly, how mobile learning can be used to support learners who code-switch while learning. Chapter 6 discussed existing translation techniques which can either be embedded in a mobile learning system to enable learners to access translated content, or be used in an external process in the case where there are resource constraints with no language specialist to facilitate the process of learning content translation. Chapter 7 will therefore present how from the previous chapters we devised a multilingual mobile learning framework which is presented in chapter 8.

7.1 Introduction

This chapter seeks to provide answers to the following research question:

Question 3: How can a mobile learning framework be used to develop mobile learning systems that support the learning process in multilingual learning environments?

In this chapter we describe how the theories supporting the approaches which can be used to develop mobile learning systems were derived. The next chapter details

a framework reflecting how mobile learning systems that support the learning process can be developed.

7.2 Literature foundation of the framework

7.2.1 Code-switching behaviour

When revisiting code-switching behaviour we should remember that it is a linguistic phenomenon that is experienced by multilingual speakers of different languages. Various explanations have been provided by researchers of why bilingual or multilingual learners code-switch. One of the most commonly cited reasons is the lack of proficiency in any of the communication languages that they switch between. Code-switching is also regarded as a strategic skill where code-switchers are able to process languages and mix them selectively to achieve their communication goal; for instance, whenever they need a replacement word they are able to separate out the communication languages distinctly and find the replacement word (Heredia and Altarriba, 2001).

There are two types of code-switching behaviour, known as inter-sentential and intra-sentential code-switching. Inter-sentential code-switching is often faced with boundaries and occurs less frequently. For instance, boundaries can emerge after every sentence or after every paragraph when the switch occurs between languages (Faltis, 1989; Graedler, 1999).

An example of inter-sentential code-switching:

Learning simultaneous equations requires an understanding *ya diplao tse di botlhofu le go di boeletsa kgapetsakgapetsa.*

Translation of the sentence: Learning simultaneous equations requires an understanding of basic mathematics and consistent practice.

The second form of code-switching, known as intra-sentential code-switching, is observed when the switch between languages occurs more frequently. It may occur during speech or writing and often has no boundaries or just limited ones (i.e. when it occurs within sentences) (Faltis, 1989; Graedler, 1999). An example of intra-sentential code-switching:

Learning *dipalo go bokete* but can be achieved ka constant practice

Translation of the sentence: Learning mathematics is difficult but can be achieved through constant practice.

This form of switch is often unregulated, as switching occurs within sentences or after every second word. It is important, however, not to confuse code-switching with 'borrowing'. Borrowing occurs when a speaker borrows a word from one language which does not exist in another language.

7.2.2 Code-switching in a learning environment

The role of code-switching in learning environments has been elevated from being merely a communication strategy towards serving as a learning strategy. Code-switching in the learning environment occurs as a result of the learning and teaching language differing from the learner's home language. In countries where the language of learning and teaching (LOLT) differs from the learner's home language, code-switching becomes a key tool in scaffolding the learning process for learners. In this context, scaffolding refers to a means of aiding learners in their understanding of material presented in language A by teaching in both language A and B. The process of code-switching is often perpetuated by the teacher's ability to converse and teach both in the LOLT and the learner's home language. Teachers use this process as a key tool to communicate learning content and tasks in more than one language (Iqbal, 2011; Setati, 1998; Fennema-Bloom, 2009). Code-

switching in schools is used in different forms and these will be explained thoroughly in this chapter.

7.3 Designing instruction for code-switchers: traditional instructional design theory

Design-based research plays an important role in developing learning content and accompanying learning activities. Understanding the design process assists educationalists in developing and designing appropriate education content and activities (Mor and Winters, 2007). For the purposes of this research we will consider the importance of understanding the design process for learning mediated by technology in a multilingual learning environment because it contributes towards the enhancement of the proposed multilingual mobile learning framework.

An elementary definition of the instructional design theory is a methodology, or methodologies, that can be used to design learning content and activities so enabling an effective learning environment (Reigeluth, 1999) . An instructional designer 'engineers' the learning process and the content to be used for learning by determining the instructional approach and the material, platform and activities used to attain a set of outcomes (Smith and Ragan, 1999: 2). Reigeluth (1999) describes the following in terms of the basic elements that help instructional designers to understand which method would be relevant for designing instructional learning material and content in a suitable context.

- (a) The approach to be used in achieving the learning process and objective; the approach to be used in helping learners to acquire or to realise an understanding of a theory.

- (b) The type of the learner: what previous knowledge and skills the learner possesses, the learner's motivation and a consideration of the different learning approaches suitable for a range of learners.
- (c) The learning environment: whether the learning occurs in an informal or formal learning environment and the content and activities that can be used to support the process.
- (d) The constraints of developing instructional material and activities (resources to design and facilitate teaching material and activities).
- (e) The anticipated outcome or goals of the instructional material and activities.
- (f) How efficient and effective is the approach in helping learners achieve their set goals.
- (g) The adoption and motivation by learners of the approach given to them.

An understanding of alternative instructional design approaches has assisted teachers and instructional designers in establishing and enhancing the learning environment. Traditionally, instructional design approaches have been dominated by the following learning models or approaches that influence how learning environments are structured and designed based on different learning approaches. Firstly, *behaviourism*: the instructional environment is modelled to provide a learner with initial learning material; the learner is subsequently monitored on how they respond to tasks or attain goals based on previous knowledge gained. Secondly, *cognitivism*: the instructional environment is centred on the process by which the learner understands the content; the model focuses on the method of processing the instructions given to the learner following an observation of the learners' behaviour). Lastly, *constructivism*: the instructional environment is focused on the construction of knowledge or learning through individual perspectives (Ertmer & Newby, 2013; Cooper, 1993).

An instructional designer must understand the benefits and disadvantages of any theory before using it to establish how they will compensate for each theory's shortcomings (Reigeluth, 1999). Many modern theories or models converging from traditional learning theories have since emerged with the objective of improving instructional design perspectives. These models also consider the emergence of technology-mediated learning approaches able to consider the perspectives affected by the use of technology in the learning environment (Semple, 2000; Laurillard, 2002; Naismith *et al.*, 2004).

7.4 The role of code-switching in formal and informal learning

In formal learning classrooms there are different reasons of using code-switching. In Setati (1998) an observational study on the different justifications for code-switching used by teachers and learners in a South African classroom, identifies three types of categories to classify the different forms of code-switching.

Language A refers to the language of teaching and learning.

Language B refers to the native or first language.

- (i) *Type A*: Reformulation - rephrasing what has been said in language A without adding any new information. This is often used in a context where content is given in language A and is not understood. It means that if the teacher wants to explain learning content in detail, they will reformulate or rephrase the content using language B.
- (ii) *Type B*: Introducing activity content – explaining a new content in language A then the same content in language B without rephrasing. This is often used when a concept is introduced to learners, to give them an initial

understanding of the topic. The teacher will use language A primarily and later move to language B to explain the same content. This is not the same as rephrasing or translation. The difference between reformulation and content activity is that, in reformulation, content is rephrased, while in content activity the content is initially created in both languages.

- (iii) *Type C: Translation*: Direct translation of the text from language A to language B.

In her study, Setati (1998) found that most of the teachers used code-switching Type B regularly (*Introducing content activity*), code-switching after a paragraph or a full sentence when introducing new concepts to learners. This teaching decision reflects that, in formal learning, code-switching often has more boundaries and will not occur regularly, particularly when a topic is being introduced. Type C (*Translation*) in Setati (1998) was not commonly used by the participants because direct translation does not commonly serve to project the original meaning of the text and so distorts understanding of the learning topic. Furthermore Setati (1998) explains that some jargon in a specialist subject area might not be available in the native languages of learners making it difficult for teachers to translate content directly from the language of teaching into the native languages of the learners.

Studying the boundaries associated with switching in formal learning, Graedler (1999) observes that the inter-sentential behaviour of code-switching in formally written text is also presented with boundaries, just as with the verbal switching practice. The switcher often limits the switch to one occurring after each paragraph or sentence. For formal learning environments in this framework, code-switching content would be created that supports a code-switching perspective which is inter-sentential and includes boundaries when it occurs (Faltis, 1989; Graedler, 1999).

Fennema-Bloom, (2010:34) similar to Setati (1998) describes three different approaches to teaching in a bilingual environment:

- (i) “Scaffolds further content acquisition”, substantiate language A learning content with a further explanation in learning language B.;
- (ii) “Check and sustain comprehension” repeats content presented in language A by explaining it through language B;
- (iii) “Scaffolds and or explains difficult elements targeted for language acquisition” in language learning subjects language B is used to explain complicated elements(i.e. words, jargon) of content presented in language A.

In another related case study, Carless (2004) observes the progress made by teachers in Hong Kong State schools in the process of implementing task based teaching. In surveys conducted with teachers, Carless (2004) found that in the formal class context teachers and learners code-switched between English and Cantonese. Some of the teachers observed that learners often revert back to Cantonese to understand a task, particularly if they found the task to be complicated when taught in language A. Learners would also revert back to Cantonese to explain concepts to fellow learners who were not proficient in language B.

In informal learning the characteristics become different. Code-switchers often depict different linguistic behaviours when learning in an informal context. Setati (1998) argues that code-switchers switch more often in informal environments as schools place boundaries on the language that can be used in classrooms. Creating an informal mobile learning activity for code-switchers requires an understanding of their learning context.

One of the greatest challenges facing teachers in creating informal learning material is also encouraging learners to learn beyond the classroom. In a closely related research study of language learning, Krashen (1976) states that informal learning context requires a rigorous approach of learning that will engage the learner in their

activity. Pelletier & Normore (2007) argue that learning beyond the classroom increases the performance of learners, especially in arithmetic related subjects. Hager and Halliday (2006) present some unique characteristics of informal learning that need to be considered. Informal learning often requires an understanding of the context to engage the learner but it also promotes the creation of learning that engages the pupil in the learning context. For this reason, informal learning is often described as lifelong learning, and presents unique challenges for the design of learning content.

7.5 Instructional design principles for mobile learning stemming from traditional learning theories

The purpose of engaging with learning and instructional design approaches is to understand how users acquire knowledge and process information. According to Ally (2004), existing learning theories can be used to support the process of designing learning systems mediated by technology. However, these theories cannot be used in isolation as they need each other to compensate for their individual shortcomings. Ally (2004) also mentions that designing instructional activities and content mediated by technology poses certain challenges: we have to consider both the user of the technology and the learning tool in the design process. Technology in instructional design can be considered as a mediating tool or a learning component contributing towards the learning process. Responding to these challenges, Ally (2004) provides three approaches for creating content to be used for learning through mobile systems:

What — Behaviourist theory can provide activities used to introduce and reinforce concepts satisfying the ‘what’ aspect of learning,

How - Cognitivism can be used to explain the procedures and principles which satisfy the 'how' part of the learning process,

Why – A constructivist approach can be used to teach the 'why' perspective, where learners establish the reason behind the learning through the use of personal knowledge constructs.

Hung (2001) suggests different activities that can be used with traditional learning theories and which are related to Ally's (2004) perspectives through learning mediated by mobile technology. The traditional behaviourist approach can be achieved through drills and other practice approaches which reinforce the learned concept (i.e. quizzes, drill-oriented software applications). Cognitivism can be achieved by providing content related to the topic origin and principles and requesting the learners to reflect on the content monitoring the manner in which they reflect. (i.e. online books, digital concept learning material and requesting them to write mobile notes on their understanding). Constructivism can be achieved through various activities and computing applications or tools that provide a suitable environment to enable learners to create knowledge i.e. empirical simulators, picture-taking. Additional to Ally (2004), Hung (2001) has contributed a theory of learners' social understanding which focuses on collaboration-related activities and platforms mediated by technology i.e. chatrooms, emails. When designing the learning material and activities for the mobile learning process, profiles can be included in the design process. Here each learner has an individual profile prescribing systematic tasks with different approaches based on the context of the learner, and therefore related to the afore-mentioned approaches (Ally, 2005).

Designing instruction to be used on mobile platforms also requires an understanding of the challenges posed by a mobile platform. The designer should be mandated to consider these constraints as they can disrupt the learning and teaching process.

7.6 Challenges and considerations in instructional design for mobile learning

Fundamental challenges

The design of any form of instruction to be used in a technology-mediated environment must consider that technology comes with both cognitive and physical challenges. In a mobile learning instructional environment, the mobile platform is often limited in the quantity of content that can be stored and so the extent to which learning material can be presented through a mobile device, especially, when the learners only have access to low quality mobile devices which present certain limits to the kind of content they have access to. It may be that the initial learning content, which is to provide the learning concept or subject foundation through which root concepts are initially taught to learners, cannot be provided through the mobile device. The mobile device would thus present only the key points of the learning content (Ally, 2005).

Motiwalla (2007) also cautions that mobile learning should be used to supplement existing traditional learning approaches but not to replace them. Motiwalla (2007) also concedes that various traditional learning theories can be used to design and support different mobile learning activities.

Ergonomic and heuristic challenges

When designing instruction to be used through mobile devices, the following ergonomic and heuristic issues need to be considered for the platform:

- Mobile devices have small screens – text presented on the interface would have to be limited and presented in micro-units (Ally, 2005).

- Content view management - there needs to be optimal navigation to enable easy movement between screens during the learning process (Ally, 2005).
- Low quality screens (Kukulska-Hulme and Traxler, 2005) – information can be presented with fewer graphics to take account of the varying quality of mobile screens, particularly if the design is targeted for low cost mobile devices.
- Visual constraints (Kukulska-Hulme and Traxler, 2005) – the information on the screen needs to be designed not to strain the learners. This can be achieved by presenting less content per page and limiting instructions per learning activity presented through the mobile device. Furthermore, content can also be presented in point format for concepts that do not require deep analysis.
- In instances where learners have to either create or gather learning content, learners may not be accustomed to gathering content through mobile devices (Kukulska-Hulme and Traxler, 2005). Here, learner inexperience can be compensated for by explaining learning activities to learners to ensure that they have a good command of the learning device, before relying on them to perform tasks that are new to them.
- Poor sound for audio-related learning activities – activities that require the use of audio on the mobile device may be confronted with low sound quality. Before creating these types of instructions there needs to be an understanding of both the quality and the types and of sound that the mobile devices can present.
- Note-taking can put a strain on a learner's hands (Kukulska-Hulme and Traxler, 2005). Mobile devices may not be used as primary note-taking devices; however, they can be used as key point note takers. Teaching or

instruction should consider presenting notes in point form to compensate for this challenge.

- Limited battery life span – learning activities need to be limited to the capacity of the mobile devices in terms of their limited battery size (Parsons *et al.*, 2006) .
- Contextual challenges – mobile devices can be disruptive in formal learning environments while they can also be difficult to learn with them in informal environments. This requires an understanding of the learning context for which the learning instruction is designed (Sharples, 2002).

These factors contribute towards the success of the mobile learning process for learners and need to be considered in the instructional design phase.

7.7 Understanding the formal and informal learning context in the multilingual mobile learning environment

In the proposed multilingual mobile learning framework, the context plays a vital role as it affects the mobile learning process and the code-switching process.

In a mobile learning environment, great emphasis is placed on the personalisation of learning. In this context, personalisation can be achieved by understanding the requirements of a code-switching learner, their control over the learning process and their engagement in knowledge creation (Laurillard, 2007) . An awareness of the learner's context (the culture of the learner, the learning tool, and the learning process) thus becomes an important factor in mobile learning. Motiwalla (2007) takes the theory of learning through mobile devices to be a supplement to the traditional learning of conversation where learning occurs in dialogue form, engaging the learner within the process. Sharples (2000:180) is in agreement,

outlining the importance of the context, in relation to the 'culture' of the learner, should be identified, along with "social" and "cognitive" aspects, as contributors to informal learning environments. We therefore need to consider the code-switching learner's cultural, social and cognitive behaviours in relation to the learning process. In addition, Sharples (2000) describes learning in an informal learning environment as a form of knowledge construction where it is necessary for the learner to reflect upon it rather than merely receiving knowledge, being that the learner also fully participates in the process. In this instance, learning should also be seen more as a two way process rather than knowledge being streamed from a single direction (Motiwalla, 2007). Cairncross and Mannion (2001) suggest the use of multimedia to ensure that this type of learning environment engages the learning and encourages them to contribute to the learning process. Following Laurillard (2007), they suggest that control of the learning activity should be given to the learner in this learning environment. Furthermore the learning process should not only require learners to replicate learning content, but learners should demonstrate their knowledge acquisition and be able to reflect on it (Sharples 2000; Motiwalla 2007).

7.8 Formal and informal mobile instructional design – the importance of context awareness

Instructional design considerations can be further divided into formal and informal learning environments. In this framework, we examine perspectives on designing instruction that consider the context in which learning takes place. Context is important because it affects the learning content and activities prescribed to learners and, in regard to code-switching practices, it also influences the learning activities suitable for both formal and informal context awareness. In both formal and informal learning environments, the mobile device can provide the learning content and the learning activities. However, the learning content must be structured

to suit the learning environments (Kukulska-Hulme, 2012). Context awareness must also consider the learning challenges associated with both learning environments. The proposed framework in chapter 8 will thus present different content and activity design perspectives based on the learning context.

7.9 A review of mobile learning frameworks

From the conception of mobile learning, varieties of mobile learning frameworks have emerged and continue to do so. This section gives a brief overview of the different mobile learning frameworks that have contributed towards the advancement of mobile learning. Researchers have categorised mobile learning according to three common characteristics: the technology-driven aspect (which includes mobility), the context aspect and the content-driven aspect (Traxler, 2007). Some frameworks encompass all three characteristics. In this section we review different mobile learning frameworks and evaluate their contribution towards presenting procedures and practices that can be used to create mobile learning environments.

Kukulska-Hulme (2012) conceives of a mobile learning framework in terms of the emerging procedures and processes that can be used to define the mobile language learning process. The framework describes the important considerations that are to be made when creating language learning content and the learning activities appropriate both for the learning context and the time in which learning occurs. In this framework, the learning context, the time of learning and the content all contribute towards the mobile learning framework. This framework makes an important contribution to the role that context-appropriate activities and content play towards achieving a mobile language learning process.

Mostakhdemin-Hosseini and Mustajärvi (2003) present a framework that emphasises the importance of creating appropriate learning tasks or activities

relevant to the mobile learning process. Similar to Kukulska-Hulme's model (2012), each type of context (formal and informal) needs appropriate content and activities to enable a mobile learning environment. This framework focuses on e-learning as the initial point of content development which can later be adapted and deployed on a mobile platform. Mostakhdemin-Hosseini and Mustajärvi (2003) also prioritize the technological features of mobile learning, and consider mobility as the initial prerequisite of the delivery platform. The mobile device used in this learning environment forms an important part of the learning process and can be equipped with wireless connection features to ensure easy transmission of learning content. The framework focuses on the physical aspect of the learning tool omitting the interaction that occurs between the human and the technology. The cognitive aspects are limited, with the framework focusing on the delivery of the learning material itself, as opposed to the route of delivery and the learning theory process. Despite these limitations, the framework summarises the technological support that is needed to facilitate a mobile learning environment so evaluating the efficiency of the technology used in the process.

Al-Hmouz and Freemans' (2010) framework is centred on adapting mobile learning towards the different learning approaches and styles of users. The framework considers adapting mobile learning components to deliver appropriate learning content that can support different learning theories and perspectives. In this framework, the information that is entered into the mobile device by the learner along with the use of sensors can be used to track contextual changes on the part of learners and so propose related learning activities and material. They also suggest that both learning content and learner information can be stored via learner profiles which also keep a record of the interaction process of each individual learner.

Clough *et al.* (2008) provide a mobile learning framework that focuses on the mobile learning context and how it affects the mobile learning process. The framework also explores how mobile learning must also be able to support the delivery of learning activities directed at both individual and collaborative learning. In this framework, the environment of interaction largely affects the outputs received from the learning process and thus the learning context forms the focal factor of the framework. This framework focuses on the context and describes briefly considerations of the technology used in a mobile learning process, while very little is mentioned about the physical components of the learning context.

Peng *et al.* (2009) emphasise the importance of learning activities that support the mobile learning process. This framework suggests different mobile learning: *components*, which include learning theories and the unique characteristics of the mobile learner; *functions*, which describe the procedures and platforms in which the mobile learning process occurs; and finally *related issues*, which include the performance of mobile learning teachers and other classroom-related issues, the performance of mobile learners, the learning platform, the infrastructure in which the mobile learning process takes place and the role of the classroom facilitator in the learning context. In this framework the facilitator should also receive training in how to introduce the new learning method and support learners through a constructivist approach to education. The authors focus on the teachers' contributions to the success of mobile learning and how the change in their perspective can support the learning framework. They also consider the ability of mobile learning to inculcate a pervasive learning environment through appropriate use of the platform in schools, and how learning content may be delivered using specific learning platforms. Peng *et al.*'s. (2009) framework concentrates on higher learning institutions and does not reflect on the interaction between high school learners and teachers in a traditional

learning environment, even though similar principles can be adapted to high school learning environments.

Sharples *et al.* (2005) focus on the outputs of mobile learning, and illustrate what type of achievements must be retained from the initial learning objectives with learners and teachers having the ability to control the learning tool. In this framework, learning can occur at any location and time, and the interaction between the learners, the mobile learning tool and the teacher must be correctly synchronised to create a well-adjusted learning environment. Furthermore the framework can also be used to analyse or evaluate the mobile learning process. The framework also places less emphasis on the mobile learning technology used to convey the learning process.

The web-based mobile learning framework of Chen *et al.* (2008) outlines both the technology and the learning model used to construct a learning environment. The framework provides a walkthrough of how the technical components function in union with the learners' perceived needs, and so concentrate on creating an adaptive learning tool. Furthermore, in this framework pedagogical information is stored in a data warehouse to be retrieved when a learner logs into an application with their details. Each user profile is characterised by their personal interaction with the learning application. The drawback of this framework is that it concentrates on the learner and his interaction with the technology, and gives less of a focus on the other attributes that affect the learning context. This framework does not reflect on the reality of the existing classroom learning environment and how teachers can facilitate a learning environment to be integrated into the model.

Koole (2009) introduces three main dimensions that converge to form a mobile learning framework.

The learning device: the technical aspects of the mobile device, capacity, input and output functionalities. When designing learning content the mobile device determines the activity that will involve the mobile device. The size and capacity of the mobile device will also restrict the activities that occur through the process of mobile learning.

The learner: the learner's cognitive capabilities, their motivation towards learning, their memory capabilities and prior learning. The manner in which learners' process learning, and the manner in which learners relate to their learning process and content affects the content and learning activities in a mobile learning environment. The mobile device not only introduces a new platform but it also introduces a new paradigm of learning and teaching. These factors affect the learner as the main user of the mobile learning process.

The social construct: the social construct refers to the context and the manner in which learners relate to each other and the learning process. Understanding the way in which learning is constructed considering these factors helps to create a suitable learning environment.

All of the above mentioned frameworks present the learner, the learning device and the context as the central contributors towards a mobile learning framework. Even though some of these frameworks consider the culture and context of the learner, none of the frameworks considered factors related to the multilingual learning process as a central part of a mobile learning environment.

The afore-mentioned frameworks each display unique characteristics in their goal of achieving a mobile learning environment. The learner, the learning context and the learning are common features of the frameworks (Koole, 2009; Al-Hmouz and Freeman 2010; Clough *et al.*, 2008, Kukulska-Hulme, 2012) . Moreover, appropriate learning content has an important role in the framework based on the learning

context (Kukulska-Hulme, 2012). An understanding of the learning theory also emerges as an important factor, as it not only affects the learner and device interaction process (Chen, 2008), but also affects the learning content, as well as related learning activities and theories that can be built around the mobile learning process (Sharples, 2005; Peng *et al.*, 2009; Mostakhdemin-Hosseini and Mustajärvi 2003). Other important issues that emerge include the mobile learning facilitator and the contribution they make towards ensuring a successful mobile learning environment (Peng *et al.*, 2009). Building on the afore-mentioned frameworks, the multilingual mobile learning framework proposed in this research will begin with an understanding of the following: the mobile learner, the mobile learning tool, the mobile learning context, the learning facilitator and the mobile learning content designed to support a multilingual learning approach. For the purposes of this thesis we consider language to be an integral part of the learning framework. Research is therefore framed in consideration of the behaviour of code-switching which is used to aid the learning process in multilingual learning environments. The focus is hence on how appropriate learning content and activities can be used to deliver learning through a mobile environment.

7.10 Lessons learnt on supporting a mobile learning process in multilingual learning environments

In Chapter 4 we established a mobile learning system which was able to support the learning process for multilingual learners in a mathematics classroom. The fundamental aim of the study was to establish pedagogy development considerations for mobile learning that is used in a multilingual formal environment. The study revealed the following.

- Learners in formal environments present a less frequent behaviour of code-switching, which is known as inter-sentential code-switching. This form of

switch needs to be considered when developing content to support learning in this context, as it also affects the manner in which content is presented to learners.

- Code-switching is used by teachers in formal learning to reinforce learning, introduce learning content and provide a translation process where learners cannot understand content.
- Traditional learning theories can be used to design learning activities for students in formal mobile learning environments.
- Mobile learning presents both heuristic and interactional challenges for learning in classrooms where teachers have to be considered in the instruction design process.

In chapter 5 we presented a mobile learning system that can be used to support learning in an informal learning environment. We also established the importance of appropriate learning activities to support learning in informal environments. In an informal learning process, less focus was placed on learning content and greater focus was placed on creating rigorous learning activities, as the same principles used for creating formal learning content can be used for informal learning. The study revealed the following.

- Code-switching behaviour occurs more frequently in informal learning environments which require learning activities and environments supporting this form of code-switching, referred to as intra-sentential code-switching.
- The same content design principles can be used to create content-based learning as in the formal learning environment. However, informal learning often encourages particular learning content, such as audio based content and chatrooms, as these allow continuous code-switching which is not

regulated by the environments supporting the intra-sentential process of code-switching.

- Traditional learning theories can be used to create learning activities that support a mobile learning process in informal bilingual learning.

These factors have been used to establish a mobile learning framework presented in chapter 8.

In Chapter 6 we presented various automated systems that can be used to support multilingual content development. Technology has yet to be developed to support learners who code-switch in South Africa. However, research initiatives exist dedicated to language in technology; notably initiatives such as machine language translation. As seen in chapter 6, when translating two different languages with no lexical similarities, machine translation becomes challenging when reproducing learning content for languages that are not related. For example, in regard to Setswana and English (Wilken *et al.*, 2012), the languages display limited characteristics making it difficult to translate the content through an automated system. In short, machine language translation in South Africa can be achieved for languages that are related. However, the challenge for a learning environment is that meanings are often distorted, while learning content needs to be precise to help a learner to understand content.

In light of the shortcomings of machine translation to support multilingual learning content, in the proposed framework we use the concept of selecting a word to see its alternative in another language presented in section 6.1. based on the principles of the another translation process, by the CText to support their online interaction with the University website.

We conclude this chapter by reflecting the following as the main factors which our proposed framework rely on.

1. **Linguistic factors** – Learners and teachers use different forms of code-switching to aid their learning process based on the context of learning.
2. **Situational factors** – Both code-switching and mobile learning processes are affected by the learning context. Considering both the learning and code-switching factors, appropriate content and learning activities are to be designed to support learning which takes account of the environment.
3. **The learning theory** – There are established learning theories that can be used to support the mobile learning process. These theories can be used in support of code-switching learning theories in order to create a multilingual learning environment.
4. **The mobile device** – The mobile learning device presents both the learning platform, and learning environment in which learning occurs. Issues of heuristics and challenges associated with mobile devices should be considered when creating a mobile learning environment.

7.11 Summary

This chapter presented the theoretical underpinning supported by the empirical studies presented in previous chapters which constitute the development process of the proposed mobile learning framework. The next chapter 8 presents the framework proposed by the thesis to provide the pedagogical support needed by mobile learning developers who create mobile learning technology to support multilingual learning.

Chapter 8

A proposed mobile learning framework to support multilingual mobile learning

This chapter presents a proposed framework that can be used to support the pedagogical design of mobile learning systems that anchor the learning process in formal and informal multilingual environments. Processes that were followed in defining the theory behind the mobile learning processes presented in this framework can be seen in the previous chapter 7.

8.1 Introduction

There are many mobile learning frameworks that provide extensive support for the development of mobile learning technology especially focusing on higher education support, but there is limited support for pedagogical development when creating mobile learning technology which can be used to support learning specifically in multilingual high school environments. The framework proposed in this chapter presents this support which is often needed by developers, by describing the factors needed in a learning system and how mobile learning systems can be developed to support the multilingual learning process in both formal and informal environments.

Traditional high school environments, unlike higher education, are often stringent learning environments which mainly use traditional teaching and learning practices that often do not accommodate the support of technology especially in places where there is a lack of basic learning resources. This framework recognises these challenges by considering the unique role that mobile learning technology can play in supporting the learning environment.

In the framework, different role players, enable a mobile learning system to occur. The role players are defined in detail in section 8.2. We then propose in section 8.3 a process that can followed to develop systems that can be used in similar contexts as the contexts defined previously in chapters 4 and 5. In sections 8.5, 8.6 and 8.7 we propose different content development approaches based on teaching and learning objectives, learning theories and approaches based on the context that the systems will be used. In sections 8.7, 8.8 and 8.9 we proposed approaches of how to customise the systems to support activities for learning based on the formal and informal context while considering the code-switching approaches of learners by presenting learning content to support multilingual learning.

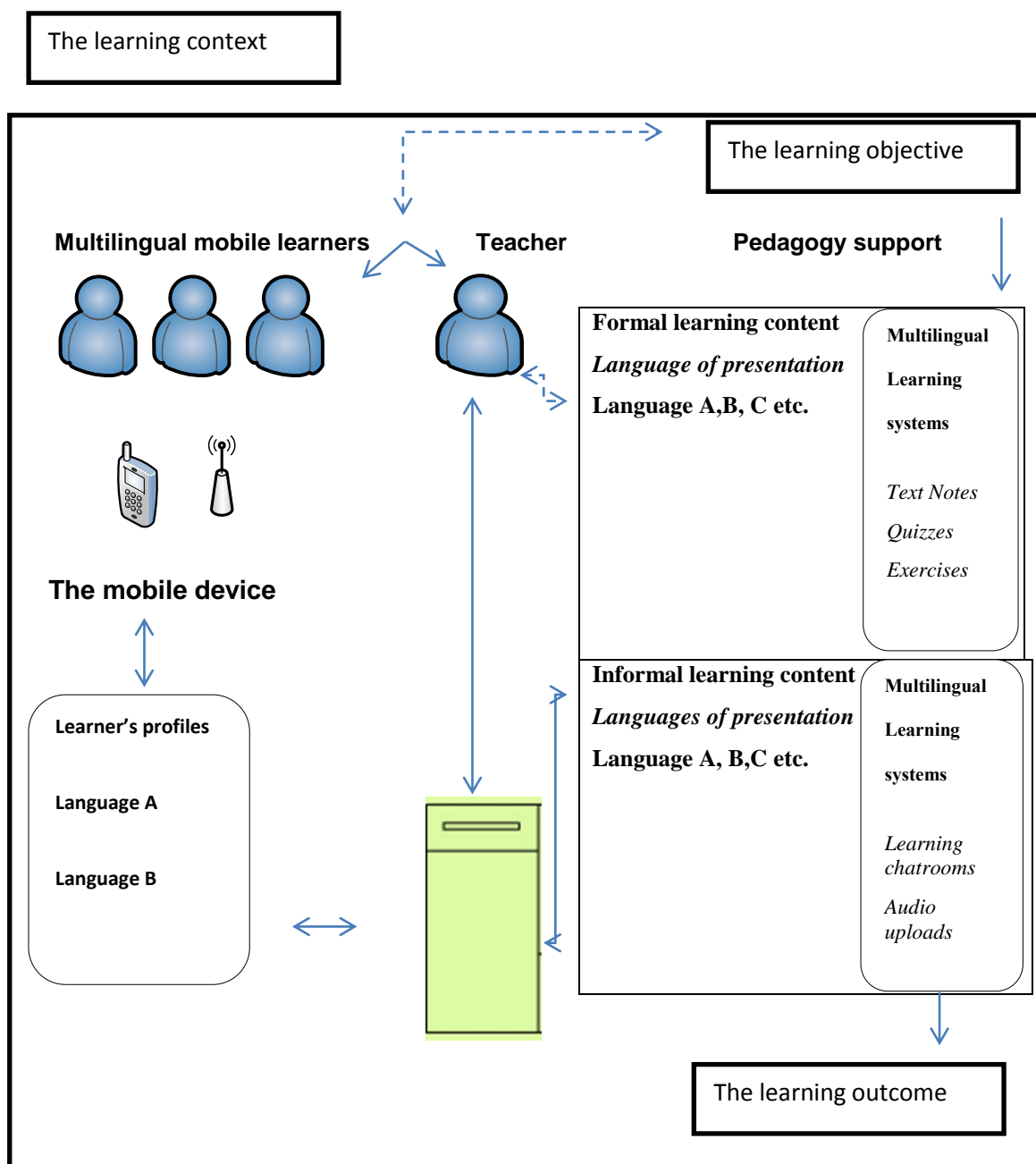


Figure 8. 1 A multilingual mobile learning framework

In figure 8.1, the multilingual mobile learners and their teachers are the main users of systems to be developed through the framework. The learners use different mobile devices to access the learning systems with each learner accessing the system with a learning objective. The teacher defines the system's role by contributing to the system content and monitoring students' progress based on the learning objectives, this is also reflected in chapter 4 and 5 where the M-Thuto

system content and use by both teachers and learners was defined by a learning objective and aims to achieve an outcome through the support of the system. Through profiles, each learner's records and their choice of languages for learning will be kept under a profile. Each interaction between learners and a mobile learning system has a learning outcome based on what the learners aim to achieve in each learning process. In providing pedagogy support, the systems will be customised for both formal and informal learning context support. In formal learning support traditional approaches of learning such as reading text books and notes, quizzes and class exercises can be made available through multiple languages within the systems as we see in section 4.4.3 which displays the different content of the M-Thuto system. For informal learning support, learning can be supported through different learning activities such as creating audio learning notes which can be catered for using storage platforms in the mobile learning systems. The system may also provide access to external or tailored chatroom facilities which are freely available to enable informal learning. The next sections details the approaches proposed by the framework discussing elements of the framework in figure 8.1 in detail.

8.2 Understanding the role players

When developing a mobile learning system in a learning environment, we should consider that the learning environment is commonly comprised of various participants who enable the mobile learning process. In the proposed framework we identify the following participants and their needs and contribution to the mobile learning development process.

The mobile learner: In chapter 4 and 5 we established the needs of mobile learners and their challenges in formal and informal school environments. In section 4.4.1 and 5.4.1 in the requirements gathering process of the system development

process we considered the learners needs by understanding how their teacher imparts knowledge in that context (formal and informal), why and what they want the learners to understand from the learning content. Equally the learner has the same objectives of what they are to learn, why they would need to learn and how they would acquire this knowledge. The mobile learner in this research is the intended user of the mobile learning system and activity. We consider the mobile learner to be a bilingual or multilingual learner who uses more than one language in any learning context through the platform of mobile devices. It is important to be aware of the bilingual backgrounds of the learners as this affects how and if they will use the bilingual support created for them. In the case studies in chapter 4 and 5, participating learners came from different language backgrounds which included the languages in which the content was available in. Mobile learners can be further defined as the main role players in a mobile learning process who passively influence the design principles so as to achieve a learner-centred system. We consider the learner's linguistic background and unique learning approaches as important factors in contributing to achieving learner-centred learning environments. When developing pedagogy for learners in any environment, learning theories and approaches will also play a vital role in supporting the human-computer interaction aspects of the learning tool. Understanding different learning theories that can be used to support learners in a mobile learning environment will aid in achieving a learner-centred mobile learning environment as we established in the development process of the systems presented in section 4.4 and 5.4.

The learning device: In section 4.7.1 and section 5.6.1 we established that the most commonly accessible electronic learning devices were mobile devices. Most of the learner participants in chapter 4 and 5 had access to mobile phones when comparing this access to other devices such as computers. The learning device described in this framework and suggested as a potential mobile learning tool is any

mobile device which is not bound by the location and can be used across different contexts. The learners in this context must be able to use the mobile platform in both mobile and situated learning activities. There are different types of mobile learning devices available in the market. This framework considers mobile devices which are both inexpensive and affordable, allowing users with different financial constraints to access the mobile learning environment. Usability considerations of the mobile learning devices also need to be considered as they play an important role in the mobile learning process. As seen in section 4.7.5 mobile devices present different challenges such as small screen sizes which can be compensated for by for example reducing the amount of content which is presented on one screen view.

As also reflected in literature (Mostakhdemin-Hosseini and Mustajärvi, 2003) when designing mobile learning material and activities the following generic issues must also be considered.

- Users may not be able to afford the financial implications of the network services - this issue can be mitigated with downloadable mobile applications as opposed to relying on a constant connection to access the learning system.
- Poor input platforms can make the process slow and frustrating to users – the mobile learning systems can be designed in a manner which does not require intense input features.
- Variation in the mobile devices used affects the system presentation – Mobile learning systems can use two versions adapting to either smart or ordinary feature devices. The system can be initially designed with simple features that make less use of graphics which otherwise demand additional features of a mobile device.

These challenges can be overcome by understanding the learning context in which the device will be used, and identifying the appropriate software design, implementation and maintenance approaches based on the contextual goals, challenges and abilities.

The mobile phone as a potential mobile device: In a mobile learning environment, access to the mobile learning device becomes an important factor affecting the mobile learning process, being that mobile devices form the central learning platform. Mobile phones are considered to be the most affordable and accessible methods of providing ubiquitous learning. In chapter 4 and 5 we found that participants had universal access to mobile phones in comparison to other mobile and electronic learning devices. Mobile phones are reasonably priced, yet provide services that are also available in palmtops. Considering the high rate of mobile phone use and subscription throughout the world, mobile phones present themselves not only as the most affordable but also the most pervasive mobile technologies for both low-income and high income users. Mobile phones can also be used to achieve different learning outcomes by using their basic features such as gathering data through video recording and picture-taking, without having to use custom software. As a result of their portability, mobile phones can be used interchangeably between formal and informal learning environments. However when using mobile phones in the learning process, the following issues need to be considered:

- Mobile devices can be both attractive and distracting in a learning process, as learners can use them for processes other than learning, these devices may need to be regulated by regulating the sites that learners can access for learning;
- Mobile device sizes can limit the functions of the learning software by being unable to cope with activities demanding features such as high memory

capacity leading to failures in utilizing mobile learning as an effective learning tool;

- The initial ease of use and straightforward fulfilment of allocated tasks through mobile learning in contrast to the conventional mode of classroom education can nevertheless pose a challenge to some learners who do not have a mobile phone-based learning background. In section 5.6.4 we established that learners even though recognising the impact of the mobile phones in providing a resource support, they still found text books to be effective in supporting their learning process.

In establishing an appropriate mobile learning device for learning, the learner's access to mobile devices remains the preliminary but key factor. In the studies presented in chapter 4 and chapter 5 there was a high ownership and high access of mobile phones regardless of the financial background of participants. These key factors strengthen the underlying argument for mobile phones as potential mobile learning devices. They cancel out issues of mobile device accessibility by demonstrating that mobile phones use amongst learners and their teachers constitutes the most pervasive learning technologies regardless of the financial means of both groups. While recognising that some of the activities proposed by the architecture cannot be carried out on mobile phones with poor features, this research considers an outlook that as the mobile phone demand increases the cost of mobile phones with good services will decrease. The research also considers a future outlook that as the demand for improved user communication and mobile data increase, different countries will improve these structures. This would then enable mobile learning of any form to occur seamlessly.

The context: In chapter 4 we established that there was less frequency of code-switching occurring in formal learning environments in comparison with the study

conducted in chapter 5. In chapter 4 the study was conducted in a formal classroom setting while in chapter 5 the study was conducted in an informal environment. The learners in chapter 5 were constantly code-switching to create learning content as part of their learning activity. Code-switching behaviour is affected by different learning contexts. In this framework, the context includes both formal and informal environments. In a mobile learning environment which supports code-switchers, the learning context affects the content presented to learners and the activities that learners can use to achieve learning. These contexts will not only present advantages but will also challenge the mobile learning process, demanding appropriate design considerations to incorporate learning in both formal and informal environments. Some of these issues include: policies that determine the language of learning (in chapter 4 and 5 while there was 1 language used for official instruction, there was an additional 10 languages that can be used to support teaching and learning with a regional use of only 2 languages in each province); the mobile phone regulations within schools affect how and when mobile learning could be used (in the schools participating mobile phones were prohibited and during the study they were used at certain times during the lesson); along with related issues such as regulating the content that learners can access for learning, these considerations will be issues raised by the learning context that need to be considered in the system pedagogy design process.

The learning language: In the studies conducted in chapter 4 and 5 the official language of instruction was English. In the study conducted in chapter 4 the native languages used to support learning additional to English were languages used within the geographic location of the school, which were limited to the Sotho group of languages. In the study conducted in chapter 5 the languages used to support teaching and learning were also limited to the Sotho group of languages. This group as explained in section 5.6 has 3 languages namely Setswana, Sepedi, Sesotho

which all members of the group can communicate with each other. Providing content in one of the languages in this group means that speakers of other languages in this group are able to gain access to content. In any multilingual learning environment certain languages will be selected to present the learning process and the learning content. The language use differs according to the code-switchers' learning context. Supporting a learner who code-switches requires an understanding of the languages used in both the formal and informal learning environments, as well as the language family of the instructional languages, because some of these languages will be related and can be used to support a larger range of multilingual learners as presented in chapter 6. We noted in section 5.6.3 of the results of the study in chapter 5 that switching could also occur commonly in one group of languages. Researchers (Brock-Utne, 2001) often point out that the poor performance of learners in African countries can also be attributed to their interpretation of second languages as mediums of instructions. This phenomenon of using more than one language to receive education is not only experienced in Africa but can also be experienced in countries where the language of learning and teaching differs from the learner's home language. It becomes imperative to understand how these languages are used to support the process of learning.

The teacher: In sections 4.4.1 and sections 5.4.1 in the requirements gathering process the teacher played the central role in designing the pedagogy of the system. The teacher influences how the technology is used in the classroom and influences when the technology can be used to support learning. The teacher thus plays the role of an instructor and an activity designer in a multilingual mobile learning environment. This framework considers multilingual teachers who work in a multilingual environment, both having to select which languages are used for learning and how they are used for the learning process. This framework also

considers the fact that not all facilitators will be conversant or skilled with mobile devices. A design approach is proposed drawing upon the teachers' contribution towards the curricula, the learning activities and the learning languages to support the code-switching process. A development process which is comprehensive and considers the perspective of the teacher will ensure that teachers also adopt the systems in their classroom to support their teaching process.

In this framework we consider pre-designed systems rather than authoring tools as the teachers targeted in the framework are generally not highly skilled in terms of having a technical background and will first have to deal with the challenge of using technology in the teaching process. Figure 8.2 illustrates the system role players reflected in this section.

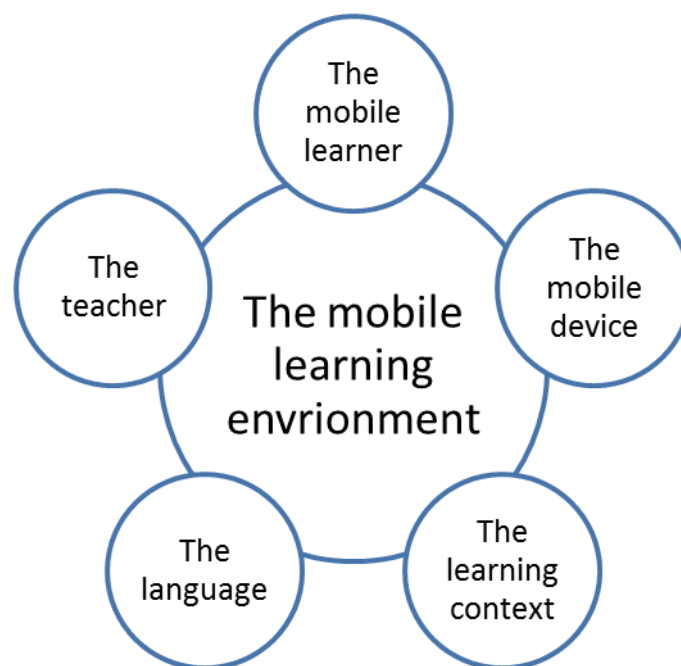


Figure 8. 2 The multilingual mobile learning role players

8.3 Developing the system

While there are many existing software development life cycle process as the one we used to develop the M-Thuto system in section 4.4, most of these processes do not consider the challenges that come with developing technology in high school environments. Existing software development lifecycles can however be chosen based on the resources available to develop a system by adapting the process. In this section we describe the approaches which we used in section 4.4 and 5.4 to develop that M-Thuto system adapting the traditional Waterfall model. In the system development processes the main initial approach is to gather the system requirements. In section 4.4.1 and 5.4.1 we present the teachers and learners as the main role players who define the systems requirements. The system requirements were thus used to establish the system objective, establish the current practice and finally to establish the new support process that the system can play in learning. In the M-Thuto system the main system requirement was to support the process of multilingual learning through a mobile learning system. The requirements were then documented.

The next process was to analyse the system requirements. When analysing the system requirements we established how the system would support learning activities to achieve the teaching and learning objectives. These were also aligned to how current teaching and learning practice occurred so as to support current practice. This process also involved understanding the contextual challenges which include the resources that would be used to develop the system, the resources that would be needed for the users to access and use the system. In section 4.4.1, 4.4.2, 5.4.1 and 5.4.2 we established the teaching and learning objectives for learning in formal and informal contexts and how code-switching was used to support multilingual learning. These objectives were based on supporting learners to learn new theory, reaffirm what they had already learnt, to allow learners to

create new knowledge and to allow them to reflect on knowledge they had already acquired.

The next process was to design and develop the system. In this process the pedagogical, the architectural and the interface structure of the system were developed based on the system requirements. In section 4.4.3 and 5.4.3, when developing learning content we then used the teaching and learning objective and traditional learning theories to create learning content to support different learning activities. The teachers defined the learning content which was presented using these theories in the M-Thuto system. Different system development software can be used as already mentioned depending on the skills and resources of the system developer. Section 8.4 describes the system development architecture approach which was based on the M-Thuto system.

A pilot of the system was then tested amongst potential users of the system which include both teachers and learners to establish the ability of the system to support learning in different learning context. After improving the system based on the users' experiences and suggestions, the system was finally implemented by allowing access to the participants to support their formal and informal learning. As we describe a system approach which does not require consistent update considering the unchanging nature of a school curriculum, updates of the system can occur at the beginning of each school term. In each stage of the system development there was a documentation of the development process, the architectural and interface design of the system. Finally chapters 4 and 5 present the users interaction with the system. While this section does not describe a defined system development life cycle it provides a basic outline of an approach which can be used in mobile learning system development based on the approach used to develop the M-Thuto system in section 4.4 and 5.4 that was adapted from the traditional waterfall model.

8.4 The system architecture based on the M-Thuto system architecture

In this section we describe the architecture of mobile learning systems and how each profile in the system can be developed based on the M-Thuto architecture. The system architecture is based on a client server structure as described in section 4.4. The client in this instance is a learner who accesses the system through their own learning profiles through their mobile devices. The other client who also plays the role of the administrator is the teacher who provides the content update of the learning system while accessing the performance of the learners. The mobile learning system is accessible through the server that can be hosted by an external company or facilitated through a dedicated computer. Dedicated hosting of the server gives the system administrator more control over the system while providing their choice of system security. External hosting provides ensured security of the server and uninterrupted access to the learning system. The choice of which method is best will be influenced by the cost of external hosting. In the M-Thuto system we initially used a dedicated computer as a server side of the system. Through an XAMPP web – server stack which consists of an Apache server, MySQL database platform, and provides an interpreter for PHP and Pearl scripts, the dedicated computer hosted the M-Thuto system. After ensuring that the system functioned appropriately, we transferred the system interface and database to an external host. This was to transfer the risk of securing the content and ensuring that there is an uninterrupted access to the system when conducting the studies in the thesis. The disadvantages of external hosting are that there is a cost related to the hosting process which might not be affordable to some system developers. The system database which can be created through open source or commercial products, stores learning content and information. In the M-Thuto system we used MySQL, an open source system to develop the database tables. Each table was

based on the different profiles below where the learning content is stored. System development approaches can also be determined by the developer. In the M-Thuto system we used web-based technology with XHTML, a web-based language used to create the system interface and the PHP scripting language was used to facilitate the communication between the database and the user interface. The following section details each user's profile in the system.

Learner's profiles: In each learner's profile the learner's *Name, Age, School, Class, Username and Password* are stored. The system presents learners with different languages which they can choose to view the content. The database thus also stores the *Language preferences* of the learners. The learners can have a preference choice of two main languages which include the official language of instruction. As we noted in the systems development in section 4.4 two main human languages were used for content development. Content can be created using multiple languages. The choice of how many languages can be used will also be determined by the amount of database storage space where the content will be stored and access provided to multilingual resources. As we describe in chapter 6 there are various external approaches that can be used to translate content in environments where there are no human translators.

Teacher's profile: Each teacher should have a profile through which they can upload the updated learning content. The database stores the teachers *Name, Username and Password*. As the teacher develops the learning activities which are influenced by the learning theories as discussed in section 8.6, the learning content to support these activities will form part of the central learning system database which they access through their profile.

Central learning system: The central learning system provides the storage for each learner's learning material and progress which the learners and teachers access through their profiles. The teacher creates the learning content for the system based on the learning objective and learning theories which provide support for the learners as reflected in detail in section 8.6. The system provides different versions of the content based on the languages that content is available through. The system contains *Class Text Notes, Summarised Mobile Books, Quizzes, Testes and Audio Notes created by the learners*. Figure 8.3 presents the central learning system

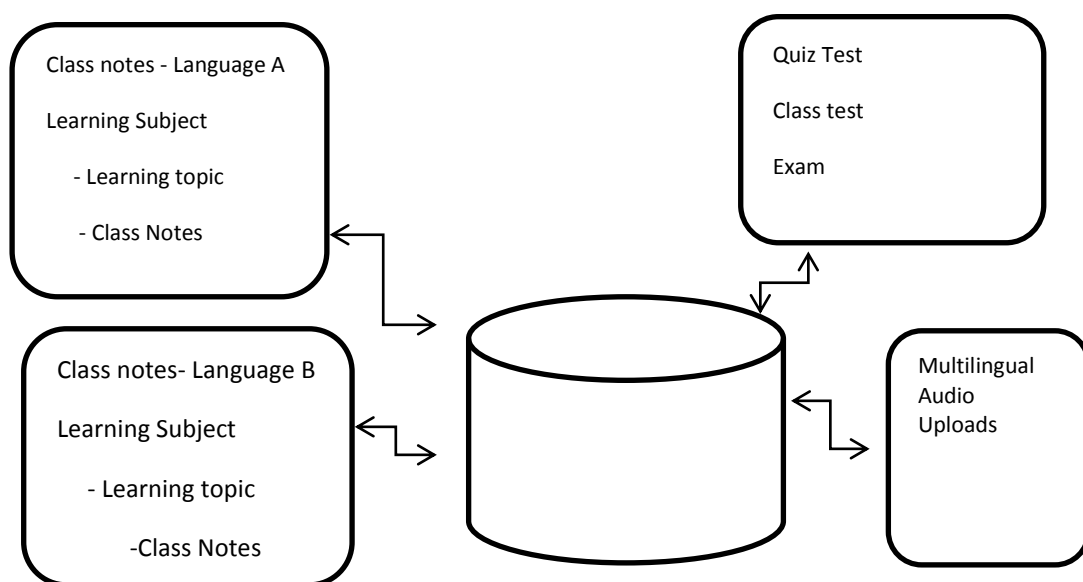


Figure 8. 3 The central learning system

In developing learning content the teacher also uses different techniques to present content to learners depending on the objective of learning. When accessing the system, also depending on the learning objective and the learning context, the learners access the learning content which will help them achieve their objectives. The details of this pedagogy outlook supported by learning theories are discussed in more detail later in this chapter. In each type of activity that the learners' access, the content is either presented using reformulation, introduction to content or translation

support which are discussed in detail in section 8.7. Figure 8.4 presents the interaction between the teacher and the learners in a mobile learning system.

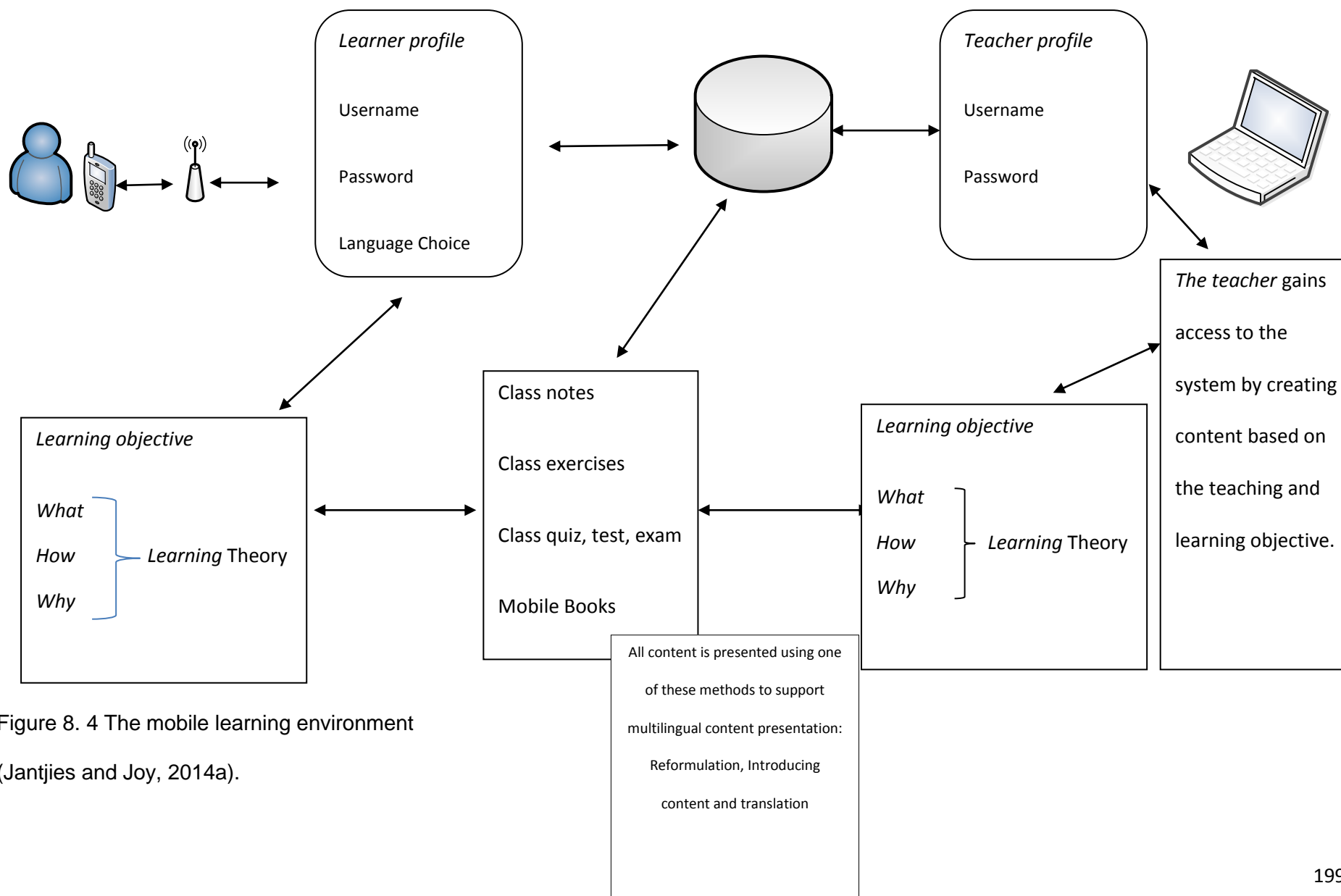


Figure 8. 4 The mobile learning environment
(Jantjies and Joy, 2014a).

8.5 The central role of the language in multilingual mobile learning systems

Language plays the central role in this framework. In section 4.7.2, section 5.6.1 and section 5.6.3, the majority of the participants were using multiple languages to assist them in learning while using the mobile learning systems presented to them to support their learning process. In every learning institution, there are regulations that govern the use of language for both formal and informal learning. These rules influence the languages used to design and to present learning content. In a multilingual learning environment these languages can be multiple. When designing and developing the learning content to be used in this environment, the instruction designer needs to have sufficient awareness of these languages to provide the learners with a variety of content in multiple languages. The choice of which languages learners prefer to use within a mobile learning system can be narrowed down by considering learners' profiles. Language is also affected by context and consideration of the way in which the language is used to present learning content can be based on the learning context. Formal learning requires formal presentation of the languages used for learning, while an informal context supports an informal presentation of the learning content. The use of a language specialist as seen in chapter 6 can be vital to this role. Machine translation can further be used to support the translation of content from one language to another in cases where language specialists will not be present to facilitate the process as seen in section 6.7 and section 6.9 where the secondary case studies presented the potential of using machine translation techniques in instances where there were no specialists to facilitate the translation of content to be used in a mobile learning system. The content could first be translated using a separate system and would later be used as content for a mobile learning system.

8.6 The pedagogy perspective of the systems

In this thesis we propose a pedagogical perspective of development which is context aware as both formal and informal learning activities and content depend on the learning context. In this section we present the pedagogy layer of a mobile learning system.

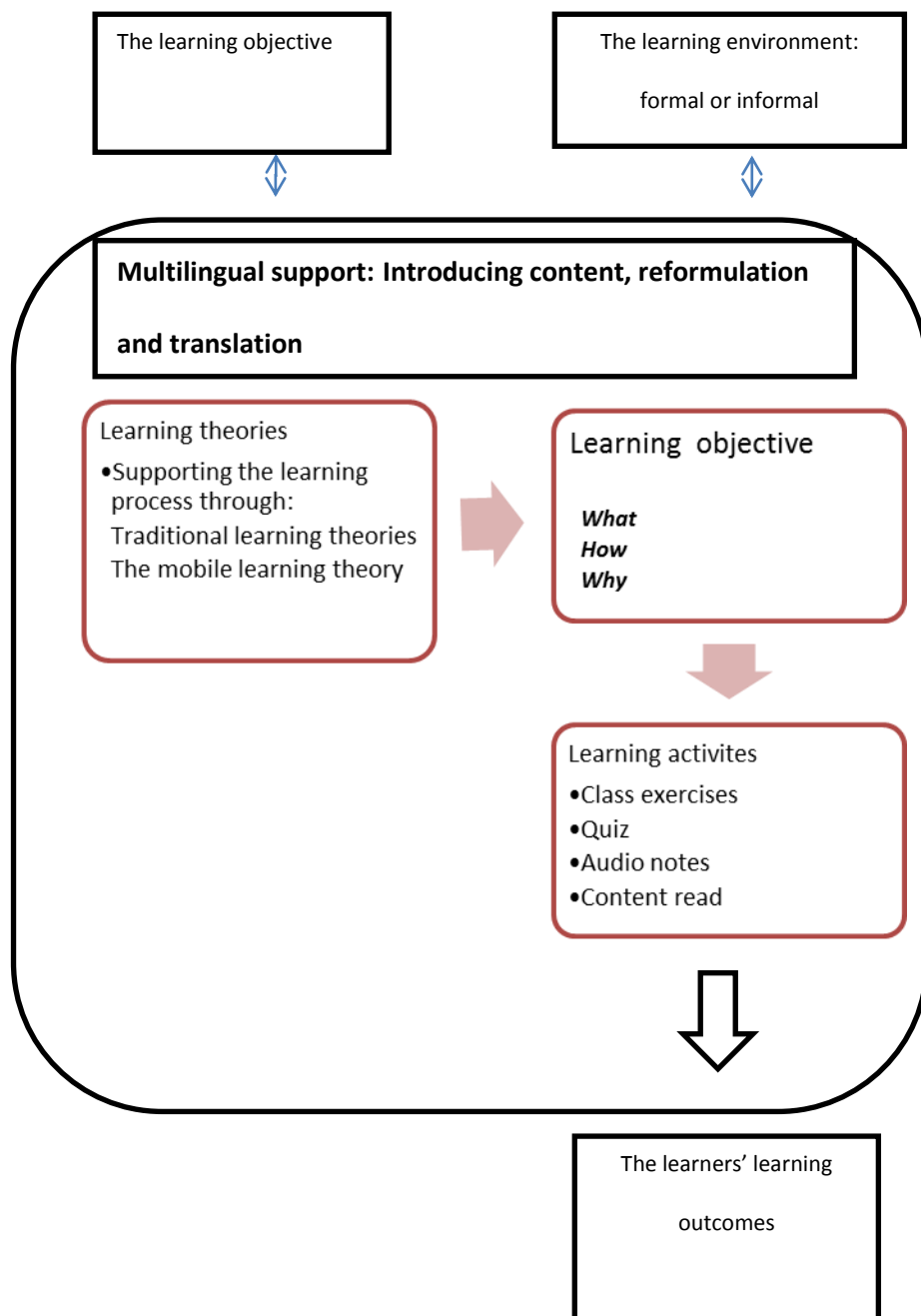


Figure 8. 5 The pedagogical perspectives of the system

In figure 8.5, we present the development approaches for the pedagogical layer of the system to be used in both formal and informal multilingual mobile learning. In section 4.4.1 and 5.4.1 we established that a teacher defines their teaching approach before conducting lessons. The first aspect of the system is to identify the learning goals and objectives of the learner while supporting the teachers teaching objective. The objectives are fed into the system based on what the teacher wants to achieve with the learning process. The teacher defines what learning the learners must achieve while learners objectives are based on what they must achieve from the learning process. These objectives will influence the outcomes which will be affected by the support of the system use for learning. Achieving the objectives can be obtained by asking three fundamental questions: the what (what is to be learned), the how (how will it be learned) and the why (why is it to be learned) of the learning process. These objectives are then supported by traditional learning theories which are used in current practice to support the process of learning. Different theories can be used as detailed in section 3.12 and 7.5 to achieve learning through the system by using each theory to provide support to achieve the learning objective. Each theory needs to be thoroughly understood considering its advantages and disadvantages as we present them in section 3.12. In section 8.7 we present how learning theories can be aligned with teaching objectives to produce mobile learning activities.

In relation to learning activities supported by learning content, both formal and informal environments present context dependent learning activities. Learning activities are also used to achieve the learning objectives both by presenting learning content to the learners and drawing upon the support of learning theories.

Language becomes the central role of the system development with every page of content and learning activity considering the consistent switch of multilingual learners while learning. The switch also becomes context dependent as we discuss in greater detail in section 8.7.

8.7 Developing learning content and activities for formal learning to support code-switching learners

In chapter 7 we established the different roles that code-switching plays in both formal and informal learning. Although we present the support based on context, the content and activities in the sections to come can be used interchangeably between formal and informal learning.

In section 4.4.2 we established how code-switching occurs in classroom learning and presented learning content to support code-switching using these considerations in section 4.4.2 and section 7.2.2 in the mobile learning system. For this research study, we propose three types of code-switching content creation based on Setati's (1998) and Fennema-Bloom's (2010) approaches when developing learning content to be used by learners in formal learning environments. The three types are: reformulation, introducing content, and translation.

In each of these three types of creating and presenting instructional content, the learning content must be pre-developed by both the teacher, and a language expert assisting the teacher. Learning content presented in different languages must be presented in the system memory. In environments where human translators are not there, translation can be used to support the content development process.

Reformulation: Reformulation as described in chapter 7 is reformulating content from one language to another. Even though there are boundaries of how code-switching occurs in formal environments, reformulation occurs more frequently as

learners require a frequent switch between content views. Reformulation may be particularly relevant to task-related learning activities or when creating content where learners need to understand more quickly what is required of them. This can be achieved by creating and presenting learning content through a subtitle view on a mobile page. The frequency (i.e. after every sentence, after every second sentence) of the switch between languages can be decided by the teacher. In this example of the M-Thuto system we presented the switch after every sentence.

For example, the concept of simultaneous equations requires a clear understanding.

Reformulation: Thuto ya simultaneous equations e batla o e tlhaloganye sentle.

An example of presenting reformulation in a mobile learning system:

The screenshot shows a mobile application interface for registration. At the top, it says 'Todays Date' followed by a date field containing '6/8/2012'. Below this are three instructions, each with a corresponding input field or set of options:

- a. Type in your name/Kwala lein la gago: [text input field]
- b. Please select your class name: grade 11 / [radio button] Tlhopa leina la phapusi ya gago: [radio button]
- c. The name of your school/ Leina la sekolo sa gago

Below instruction 'b', there are five radio button options labeled 'a', 'b', 'c', 'd', and 'e'. To the right of the form, a text box contains the following text: 'Each instruction was reformulated to give the learner an immediate understanding of the content'. Two arrows point from this text box to the input fields for instructions 'b' and 'c'.

Figure 8.6 Reformulation (Jantjies and Joy, 2014a).

Introducing content: Introducing content is a less frequent form of code-switching which is often bounded by paragraphs. The approach is often used to introduce content to learners through notes presentations. In this case, a concept is initially explained in a paragraph using language A. Language B is then used to present the same concept through a different language. This type of switch is often contextual where learners are required to understand a concept holistically before attempting a

related task. The example below provides the M-Thuto notes section which presented learning notes in English and the same notes in Setswana after paragraphs.

For example, the BODMAS rule states that in BODMAS we begin with brackets and then we continue to division, multiplication, addition and finally subtraction. The sequence follows the BODMAS word in an orderly fashion.

Introducing content: Mo molaong wa BODMAS re simolola ka maparego a rona, re be re tlhakanya, re be re ntsha dipalo tsa rona. Molao o o batla gore o diriwe ka lenaneo le le tlhalosiwang go bona karabo e e matshwanedi.

An example of presenting introducing content on a mobile learning system:

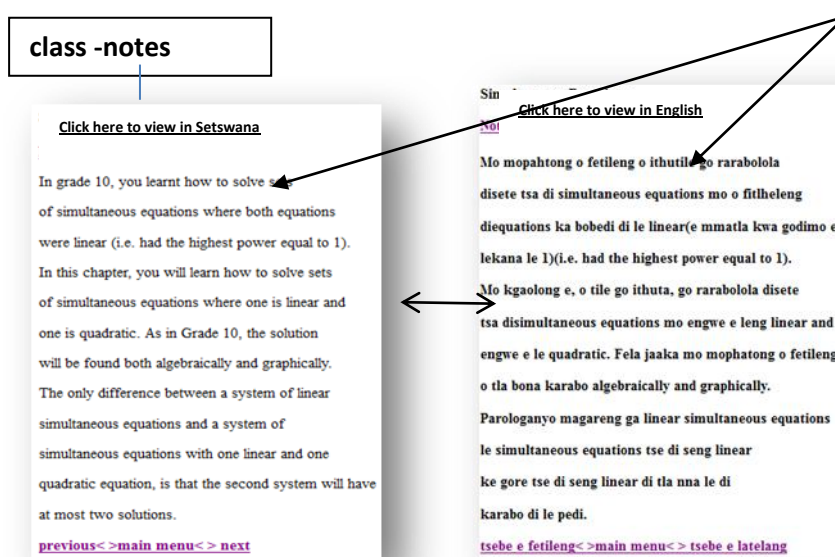


Figure 8. 7 Introducing content (Jantjies and Joy, 2014a).

In a mobile learning environment this form of switch needs to be supported with optimal navigation features so as to allow the learner to switch whenever they feel that they have grasped a concept or need to revisit the concept in another

language. Navigation should allow learners in the same content view to select through content to view in another language and be able to return to previous menus.

Translation: Direct translation is not frequently used in classrooms to facilitate the code-switching environment because the direct translation of words often distorts the meaning of the content. In this study, we suggest an alternative approach to translation, one that gives learners an option to view an alternative word in another language. We propose a feature developed by the CText discussed in section 6.2 that allows the learner to click on a word and a pop-up appears with a list of alternative words in another language. This feature has been discussed in detail in section 6.2 and 6.3 of chapter 6. The advantage of having this option available within the same learning page is that learners are given the opportunity to seek an immediate translated meaning of the word while reading text without having to move to another page or leave the mobile learning system to view a translated word on another resource such as the Internet.

An example of supporting translation techniques on a mobile learning system

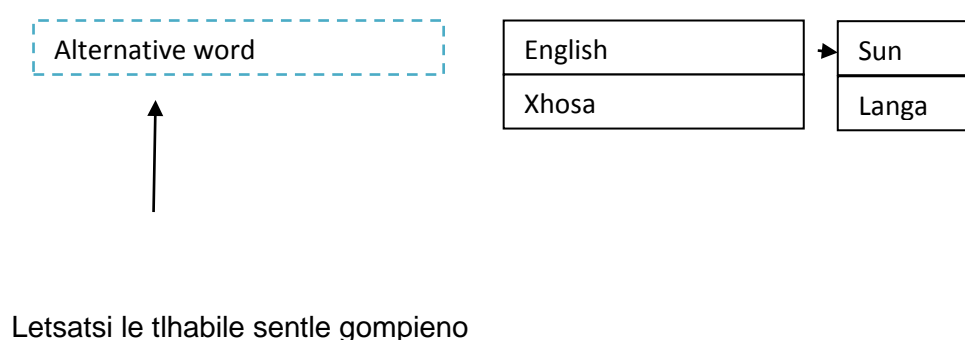


Figure 8. 8 Translation (Jantjies and Joy, 2014a).

When developing learning content to be presented in the afore-mentioned forms, the teacher or instructional content developer needs to develop the content initially

and consider the different forms of presentation, for this will affect the sequence in which the content is presented in each page view.

8.8 Supporting the mobile learning activities for formal learning environments

In section 4.4.2 and 5.4.2 as already mentioned, we established that teachers presented teaching and learning objectives which are based on traditional learning theories to support learning in both formal and informal contexts. The objectives were often based on allowing learners to create new knowledge, to reflect on knowledge that they had already acquired and to acquire or gain new knowledge. The teachers commonly used the behaviourist and the constructivist learning theories to support the process of imparting learning. The approach used in this framework for designing mobile learning activities are based on traditional learning theories also employed by different researchers to realise the mobile learning process (Ally, 2004; Naismith *et al.*, 2004, Hung, 2001). Based on Ally (2004)'s content development techniques and presentation, and in addition to the aforementioned code-switching presentation model, content must be displayed based on the learner's progress with their preferred learning activities and languages in order to facilitate the learning process. We propose using the teacher's objective and supporting them with learning theories to create learning content to support learning activities. This can be achieved by creating profiles for each learner in agreement with Al-Hmouz and Freeman (2010) keeping a record of the learner's details and their progress.

Learning activities related to the mobile learning process have been explored quite thoroughly in a number of different projects. In this thesis we propose that the same methods can be used in a high school learning context to support multilingual mobile learning. Learning activities can be used in relation to learning theories to

achieve different levels of learning. In this research we suggest the following methods as some of the ways in which mobile learning can be used to support formal learning activities.

- Introducing a new learning concept in formal learning environments or reiterating a new concept can be achieved by using the *behaviourism* approach when designing related learning activities. The learner is subsequently monitored on how they respond to tasks or attain goals based on knowledge previously acquired. Using mobile notes learners can be presented with text notes related to a new topic. As the theory can also be used to support learners to remember what they had been taught through a drill approach process, mobile learning is able to provide this support. The traditional behaviourist method can be achieved through drills and practice approaches which reinforce the learned concept (i.e. mobile quizzes and drill oriented software applications). An example of this approach can be seen in Jantjies and Joy (2012).
- Evaluation of learners' understanding of initially presented learning content, allowing them to reflect on the learning process or concept, can be achieved through the use of the *cognitivist* learning approach. *Cognitivism* is an approach which focuses on the process by which learners understand content. The model pays attention to the method of processing instructions which have been given to the learner. Cognitivism can be achieved by providing content related to the original topic and its main features (i.e. online books, digital concept learning material), as discussed in a number of studies (Hung, 2001; Ally, 2004; Jantjies and Joy, 2012) and establishing how learners create knowledge through assessment processes such as mobile based tests.

- Allowing learners to create their own learning process can be achieved through the constructivist approach. *Constructivism* in the instructional environment is focused on learners constructing knowledge or learning through individual perspectives (Ertmer, *et al.*, 1993; Cooper, 1993; Sempler, 2000; Laurillard, 2002). In the mobile learning environment this can be achieved through activities that enable learners to reflect while learning. Mobile learning systems can provide mobile notes to support them in acquiring knowledge that will support their reflection process. An example of this approach can be seen in Jantjies and Joy, (2012) .Constructivism can also be supported through mobile learning activities such as picture-taking activities and learning activities that require learners to create audio clips reflecting on what they have learnt. An example is provided in Jantjies and Joy (2013). The teachers and learners will then replay the clips to establish if the learners were able to create their own knowledge.

There are many existing learning theories, in this research we used theories which have been commonly used to support the mobile learning environment and which are also mainly used in high school learning. While in this section we provide pedagogy support by merging teaching and learning objectives with traditional learning theories, mobile learning should be primarily used to aid learners to achieve the learning objectives. Learning theories should thus only be used as a supportive theory of the objective as they cannot precede the learning objectives.

8.9 Supporting learning content and activities for informal mobile learning to support code-switching learners

While learners in informal environments require learning support which considers their constant switch between languages, they also require learning content and activities which are engaging and overcome the challenges by focusing on learning in an environment which can at times pose many distractions.

In section 5.4 we established how code-switching occurs in informal learning and presented a mobile learning approach to support learning in this context. We also established that learning objectives in informal contexts are often aimed at allowing learners to reflect on their learning that occurred during lessons. Other objectives also include creating new knowledge to prepare the learners for lessons to come.

In this section we thus describe providing the same content as the previously described in section 8.8 while extending systems to consider the informal learning context with related activities as seen in section 8.10

When supporting code-switching in informal learning we thus propose learning content which makes provision for the constant switching nature. Audio related content which can be provided by both the teachers and learners provide flexibility in supporting the constant switch between languages as they do not restrict how many times a switch can occur when the audio content is created. In a mobile learning system, portals as seen in chapter 5 can be used to keep record of audio learning material which learners can use to support their informal learning process. Chatrooms which learners can use to post questions and to share learning material also provide constant switching support as they do not restrict how learners switch between languages while learning.

8.10 Mobile learning activities for informal mobile learning environments

In section 5.4.2 we established that learners would require engaging learning activities in informal environments due to the distractions that come with informal learning. In a digital age where lifelong learning material is being improved, Dowens (2010) describes the importance of seeing the learner as a potential creator of learning instead of just a passive subject provided with learning material. The approaches provided in this model have their origin in the arguments that propose learning as a two way process in an informal learning model (Motiwalla, 2007). Moreover, an informal learning model allows the construction of knowledge and reflection of knowledge in an informal setting (Sharples *et al.*, 2005). Based on Laurillard's (2002) perspectives on instructional mobile learning design, the following learning activities are proposed for a code-switching enabled mobile learning environment. These methods are suggested based on their ability to engage a learner in a learning process that exploits the mobility of the learning content and tackles the afore-mentioned challenges that are associated with the informal mobile learning context.

- *Creating and engaging with learning content:* Being that code-switching learners switch on a regular basis in informal learning environments (Setati, 1998; Graedler, 1999), voice-recorded activities will not restrict the amount of code-switching that can occur during their learning process (one of the main considerations in using audio related learning). Learning content can be created by mobile learners through text notes, voice clips or video clips. An example of such an activity is creating voice clips of learning material gathered through different sources (lessons, text book material and online learning portals). This process engages the learners and enables them to participate in the learning process without restricting their language use

Examples of this can be observed in studies Jantjies & Joy (2013) and Hsu *et al.* (2008). It also gives the teacher an opportunity to retrieve the learning material and assess the degree of learner understanding by allowing for the revisiting of topics that pose a challenge to learners. Furthermore Cairncross and Mannion (2013) emphasize the ability of multimedia-enabled learning activities, such as camera or video recording, to engage learners much more effectively than with a traditional form of learning. Audio recordings have proven to be effective in language learning environments because learners are able to record conversations and revisit the lessons (Reinders, 2010) or listen to pre-recorded lessons (Thorton and Houser, 2005) . Audio based learning can also offer similar support to code-switchers, using languages with which they are comfortable across different subject areas in their learning process. In a related study, Kukulska-Hulme and Shield (2008) also present the popular perspective of using mobile phones to engage language learners to create their own content, describing it as commonly used method in language learning. Even though audio-recorded activities present similar types of benefits, audio or voice clips are often easier and affordable to transmit even on inexpensive mobile platforms. In related studies of language learning, multimedia mobile learning has been used to enhance the process of mobile language learning. Multimedia approaches (Hsu *et al.*, 2008; Shih, 2005) are also able to exploit mobile device features such video-making. Kukulska-Hulme (2009) reports on a project where mobile phones were used by second language speakers to record daily experiences related to their language learning processes. Voice-related multimedia activities have been cited by Hsu *et al.* (2008) and Shih (2005) as being appropriate for language-related learning, because learners can easily reflect on language when engaging in this activity. Such activities provide reflective learning which is enabled by replaying the learning

content. Chinnery (2006) literature review of mobile language learning describe voice clarity challenges as audio-based learning approaches, especially where the audio features of the mobile device are not of a high quality. In this instance, headphones are able to compensate for these limitations.

- *Exploring learning content:* Content created for learning, such as drill exercises and quizzes, also constitute activities for enabling an informal learning approach that engages the learner (Lonsdale *et al.*, 2004). For instance, quiz contents can be presented in different languages giving the learner an option to choose the language of content before beginning the learning activity (Lonsdale *et al.*, 2004), or the learner can be given the possibility of navigating at any time between languages an example of this process can be seen in Jantjies and Joy, (2012) and section 8.6.

8.11 Discussion

In this chapter we aimed to establish the following question:

Question 3: How can a mobile learning framework be used to develop mobile learning systems that support the learning process in multilingual learning environments?

In this chapter we describe the pedagogical perspective of how mobile learning systems can be developed to support multilingual environments. We proposed the approaches through a framework that can be used to support the development of multilingual mobile learning systems. In the framework we begin by understanding the different role players and their contribution towards mobile learning systems. We then describe the architectural development of the M-Thuto system reflecting on how similar architectures can be achieved. We also present a development approach that can be used which can be adapted from any existing system

development life cycle. The framework then explores how learning occurs in formal and informal environments. Through supporting current teacher practice the framework describes traditional learning theories and teaching practice which can be used with the teaching and learning objective to create learning content and activities to support high school learning. The framework thus describes three main questions that are to be used in creating a mobile learning systems, asking *what* is to be learnt, *how* will it be learnt and *why* will it be learnt. In answering these questions, mobile learning content can be modelled to support traditional teaching practices and learning theories such as behaviourism, constructivism and cognitivist approaches to enable mobile learning to occur in different context. The framework then explores how learning occurs in multilingual environments and how presenting content through mobile devices can be used to support learners who code-switch. Based on current practice, in the framework we describe three approaches that can be used to present formal learning content which are introducing content, reformulation and translation. In informal learning environments we describe how content can be supported through audio related activities and environments such as chatrooms which allow for constant switch between languages. The objective of the framework is to support the development of the pedagogy aspect of a mobile learning system to be used in multilingual formal and informal learning high school learning environments with limited resources.

8.12 Summary

In this chapter we described a multilingual learning framework which considers the multilingual mobile learning environment, the learner, the teacher and the mobile learning device as key contributors to a learning system in a mobile learning environment. We answered the third research question which establishes how a mobile learning framework can be used to develop multilingual mobile learning

systems. In this chapter we described the code-switching behaviour in a formal and informal learning environment and how instructional content can be designed to support these contexts. The proposed framework describes different learning activities that can be used to facilitate a mobile learning process which supports code-switchers through content. The framework also proposed different content and activity design perspectives, based on teaching and learning objectives and learning theories that can be used to support multilingual learning in both formal and informal contexts. The following chapter 9 will present the evaluation studies used to validate the framework from the learner and the teacher's perspectives, playing the role of the instruction user and instruction expert.

Chapter 9

Evaluating the multilingual mobile learning framework

In Chapter 8 a mobile learning framework was developed to support the development of mobile learning software. In this chapter we evaluate the practicality of the principles of the pedagogical design and implementation of multilingual mobile learning systems proposed by the framework.

9.1 Introduction

The evaluation study was based on feedback from potential users of the systems developed using the mobile learning framework. The evaluation study was limited in that a collective of linguist specialists, programmers, education technology designers and teachers would otherwise be needed to evaluate the framework. No one individual can provide all of these expert opinions and we preferred to keep evaluation within a practical educational context. Hence, we concluded that the appropriate people to evaluate the framework were the teachers and learners who would be potential users of multilingual mobile learning systems.

It should be emphasized that teachers who teach in multilingual learning environments not only understand the challenges that multilingual learners face, but they also design pedagogy on a daily basis. Moreover, their teaching practices support the code-switching behaviour of learners. We should also remember that it is the teachers who create the content to be used in a learning environment and design the activities used in support of the learning process. As both the pedagogical designers of the systems and potential users of the systems, teachers remained the ‘practical’ experts who could provide a practical and critical evaluation of the framework’s features and attributes. The learners consulted for this study

were potential multilingual mobile learning systems users themselves, who learning systems would be used to support.

9.2 The research methodology

An interview study was conducted based on the research questions outlined in section 1.2. The purpose of the evaluation process was to investigate whether the design perspectives prescribed by the framework in Chapter 8 were effective in supporting both formal and informal learning environments. The evaluation tackled two main objectives: firstly, the practicality of the mobile learning systems developed through the framework in supporting multilingual learning in formal and informal contexts; and secondly, the practicality of supporting formal and informal learning activities.

The evaluation process focused on two areas:

- ❖ Multilingual support – evaluating the proposed pedagogical approaches in terms of the ability of development principles to support the code-switching nature of multilingual learners
- ❖ Learning support – evaluating its ability to support different learning activities with the purpose of enhancing the mobile learning process.

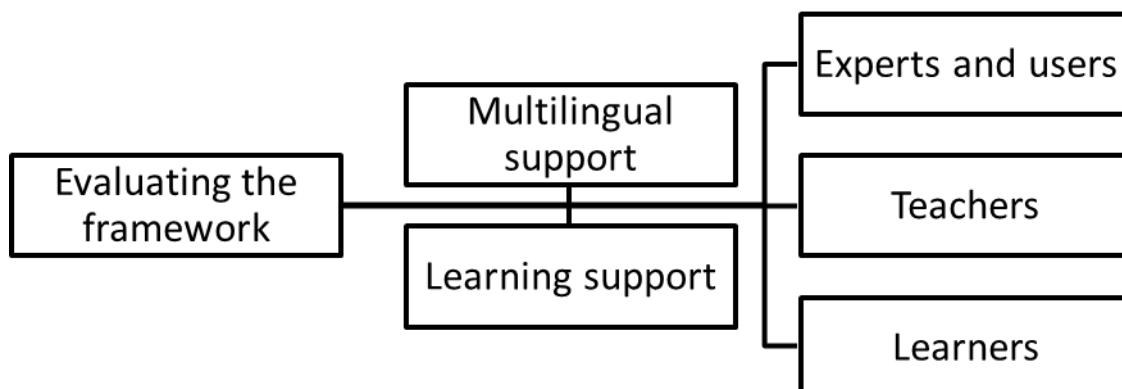


Figure 9. 1 Evaluating the multilingual mobile learning framework

In the first evaluation process, a request was sent out not only to teachers from the schools that had participated in the projects outlined in Chapters 4 and 5 but also to other schools within the province. The types of schools in which these teachers taught were similar to those described in section 4.3. The number of participants was limited to the participants which we had been granted access to; namely, teachers from the schools within the province to which I was granted access to conduct this research. Although other methods of sampling were potentially available, the method that Bryman (2012) refers to as '*Convenience* sampling' was the only method that could enable me to access participants effectively. Convenience sampling refers to the sampling technique where the sample size is limited to the participants which the researcher can access.

Through a voluntary process of participation, each teacher was interviewed individually for a period of an hour in a semi-structured interview process. A total of eight teachers participated in the study. All teachers either taught mathematics or science as explained initially in the beginning of the thesis in chapter 1, these were

key subjects which learners struggled to perform well in. It was difficult to obtain more participants as the teachers and head teachers of the various schools cited the challenge of managing high workloads and thus being unable to dedicate time to other activities. Other constraints which limited the sample size include government regulations which control how much time can be spent doing research with teachers so as not to distract them from giving lessons. All of the participants were middle and high school teachers and they complained in turn about heavy workloads and much pressure to complete the curriculum. All of these factors made it difficult for a large number of teachers to participate in the study.

In the second evaluation process, we chose to assess the framework with students from a country that was already using bilingual technology to support learning. To obtain a clear evaluation process and ensure the validity of the evaluation process, we decided that students from only one country would participate in the study. The concern was that students from other countries would display different educational and linguistic policies. In maintaining consistency on the background of participants, we chose China as a comparative model to South Africa as it has also recently introduced English as part of their teaching and learning languages and thus education technology has been adapted to support this through the availability of bilingual learning content. South Africa on the other hand, is struggling to make education technology available in both English and its native languages.

China was also chosen based on the fact that there were a high number of students on the University of Warwick campus available to participate in comparison with students from other multilingual countries. As a result of lack of access to high school learners in China, we worked with students who had just completed their high schooling in China. China has a high number of mobile phone subscriptions reflecting the high ownership of mobile phones which can be potentially used for

mobile learning. The Chinese market provides different types of mobile phones at different prices, making these devices accessible to people from different financial backgrounds (UNESCO, 2012a). According to the Internet World Stats (2013) website, Chinese is the second most used language on the Internet after the English language.

As countries continue their progress towards greater globalisation, improved communication in previously monolingual countries has become an important educational policy. Countries such as China have made progress in introducing English as one of the languages that children are to learn in primary school and through their high school education (Hu, 2005). These reasons have influenced the decision to work with students from China.

It is important to note, however, that China, unlike South Africa, uses Chinese / Mandarin and other connected languages as the languages of instruction so English is taught as a foreign language in state schools, which are funded by the government. The situation is different for private school education in China, where parents pay full school fees, as English is the language of instruction in such schools (Jin & Cortazzi, 2006). These factors cannot be generalised in every school as different factors such as rural or urban location and provincial location affect the way language is used in Chinese schools.

Once again for the sample of the students, the *convenience* sampling technique was used. This decision was justified by the degree of access that we had to these students which, as is explained above, was greater in comparison with students from other countries who displayed bilingual learning characteristics (Brynam, 2012). A request was sent out for voluntary participation to different Chinese student societies on the University of Warwick campus. A total of twelve students

volunteered to participate. We conducted semi-structured interviews with each one of them which lasted forty five minutes each. We chose to work with students who had had some recent experience of high school education; namely students who had just only spent two months in university after completing their secondary schooling. For the purpose of this chapter we will refer to participants as 'students' rather than learners as all of them were university students.

Both the interviews with experts and system users were recorded and later transcribed. The questions raised in the interviews combined both questions and scenarios emanating from the framework proposals. As mentioned in Chapter Two's description of the research methodology, a thematic analysis approach was used to analyse and present the findings throughout all the data collection processes. When reporting the results, fake names were used to protect the participants in both studies.

9.3 The experts evaluation - multilingual teachers

The following themes are derived from the framework in chapter 8. Each theme establishes the role and practicality of the framework proposals. In section 9.4.1 we link back the perspectives of the teachers to the framework to establish the validation of the framework proposals.

9.3.1 Relevance of multilingual support in the mobile learning process

The first evaluation questions in this category established the relevance of providing multilingual support to mobile learning. The objective was to establish whether the teachers used any form of code-switching to support learners in the classrooms. We also posed questions that established what their school policies were with regard to language use. In the framework in section 8.2 and section 8.5 we describe the importance of knowing the school, its regulations and its geographic location before

choosing the languages which can be used to support learning. Such information can reduce the time of content creation because the languages between which the learners switch are narrowed down to the languages of the geographic location and to the languages that the school uses. This does not restrict the use of any other languages within the specific geographic location since this can be achieved with the necessary resources.

Table 9.1 represents the different teachers and the types of schools within which they taught to highlight the difference in perspectives. These perspectives were also affected by the type of schools within which the teachers work. These schools are outlined in detail in section 4.3.

Teacher name	School location
Teacher 1, 2, 3, 4	Rural based schools similar to school C and D in section 4.3.
Teacher 5	Location based school similar to school B in section 4.3
Teacher 6,7 and 8	Urban based school similar to school A in section 4.3

Table 9. 1 The participating teachers

In representing each of the four types of schools described in Section 4.3 of Chapter 4, each teacher had a different perspective on the languages they use in school and the regulations concerning their use. All the teachers responded that there was one official language which they used for teaching which was the English language. All the participants, except teachers 6, 7, and 8 responded that school regulations did not restrict the use of other languages for teaching. However, teachers 7 and 8 also

highlighted the fact that, as they taught in former model C schools, these schools were multiracial schools and followed a strict approach to which languages could be used in class. In essence, only the English language could be used for teaching in these types of schools.

Nonetheless, it was interesting to note that, while also being based in an urban multiracial school, teacher 6 had a different perspective. Teacher 6 understood that the school promoted the use of the English language alone in classroom teaching. Yet the teacher in the said school was allowed to support learners in native languages when they felt that these learners could not follow the current lessons due to language difficulties. Of the participants, five teachers (teachers 1, 2, 3, 4 and 6) code-switched between English and Setswana, Sotho and SePedi. In contrast, only three teachers reflected that they never code-switched while supporting learners to understand. It was interesting to note that of the three participants (teacher 5, 7 and 8) who did not code-switch, one of the participants was an Afrikaans first language speaker (teacher 7), while the other participant, teacher 5, was a foreign expat teacher. Both of them taught learners who were neither English nor Afrikaans first language speakers. The last of the three teachers (teacher 8) was a Setswana first language speaker who was nonetheless strict in the language use in class being that they were concerned that learners needed to understand and use the English language without the support of other languages. Nonetheless, these teachers reflected on the challenges that the learners sometimes faced as a result of linguistic barriers (Jantjies and Joy. 2014b).

The four schools were based in an area that predominantly spoke languages from the Sotho group, where Setswana was commonly used for communication. While other language speakers also lived within the geographic location of the schools, the teachers reflected that they mostly taught learners from Setswana-speaking

backgrounds. It was interesting to note that learners from other language groups living in the same geographic location also communicated in Setswana.

9.3.2 Supporting code-switching in formal and informal learning

The second evaluation question assessed the current practice of using code-switching in class. After listening to teachers' account of using code-switching in class, the teachers were asked for their perspectives on how they used code-switching to support classroom learners. They were then asked if they found the different code-switching support features provided by the framework to be effective in supporting learning. The framework provided three main methods of using code-switching in section 8.9. In the first and second feature: to introduce topics and to reinforce what the learner had already been taught. The third feature suggested by the framework is word-to-word translation which can be obtained when a learner clicks one word in a paragraph and obtains a translated version of the word. Of the eight participants, five of the teachers (teachers 1, 2, 3, 4 and 6) frequently used code-switching to introduce and reinforce content to learners. The remaining three teachers used none of these techniques because they were strictly bound to using one language to support learning in their school. All the teachers attested that they rarely translated content and never felt a need to do so. Being that the participants were mathematics and science teachers, they reflected on the challenges they faced in these subject areas, especially when reinforcing what they had previously taught and having to code-switch frequently in the realisation that language is a barrier to learners. After being presented with the framework suggestions on supporting code-switching for the content in question, seven out of the eight participants judged that reinforcing content was the most important aspect of code-switching used in classrooms, with direct translation being the least used. Being that all code-switching occurred verbally, we then presented the teachers with the following diagram with the purpose of asking which of the three following methods

would be best in supporting written formal multilingual learning content switch. The three methods were: introducing content, reformulation and translating.

<i>Colum A: Introducing content of</i>	<i>Colum B: Reformulation</i>	<i>Colum C: Translation</i>								
<p>The capital of city of South Africa is Johannesburg with Cape Town providing the administrative home of parliament.</p> <p>Motsemoshate wa Afrika Borwa ke Gauteng. Mme Kapa Bophirima ke kwa mmusong was naga.</p>	<p>Today's Date: <input type="text" value="6/8/2012"/></p> <p>a. Type in your name/Kwala leina la gago: <input type="text"/></p> <p>b. Please select your class name: grade 11 /</p> <p>Tlhopa leina la phapusi ya gago:</p> <p><input type="radio"/> a</p> <p><input type="radio"/> b</p> <p><input type="radio"/> c</p> <p><input type="radio"/> d</p> <p><input type="radio"/> e</p> <p>c. The name of your school/ Leina la sekolo sa gago</p>	<table><tr><td>The</td><td>sun</td><td>is</td><td>Out</td></tr><tr><td></td><td>Letsatsi</td><td>le</td><td>Tswile</td></tr></table>	The	sun	is	Out		Letsatsi	le	Tswile
The	sun	is	Out							
	Letsatsi	le	Tswile							

Table 9. 2 Providing bilingual support for code-switching during learning

When supporting code-switching through written content presentation, seven of the eight participants (teachers 1, 2, 3, 4, 6, 7 and 8) preferred column A as the most important way of introducing content to learners. The remaining teacher preferred the use of column B (teacher 5) to introduce content to learners.

When reinforcing content, five of the eight participants (teacher 1, 2, 3, 4, and 6) cited column B as the most relevant to reinforcing what the learners had already been taught. Teachers 5, 7 and 8 still felt that column A was effective in reinforcing what learners had already learnt.

It is important to note that the first column A provides a paragraph presentation in language A followed by the paragraph presentation in language B. Column B, on the other hand, provides a different language after every sentence. It was interesting to note how column C was not favoured by all the teachers who stated for the most part that it does not give the learners “quality learning material”. Comparing the participants’ results, we found that the teachers preferred column A and B as a way to introduce content and reinforce what they had previously learnt (Jantjies and Joy, 2014b).

9.3.3 Supporting current practice of teaching and learning through mobile learning

In this section we established how teachers currently conduct lessons to provide learning and proposed the use of mobile learning to support current practice. The teachers were asked about the manner in which they prepared for lessons, taught learners and, most importantly, how they used technology to support learners in their formal and informal learning process.

In relation to current use of technology, none of the participating teachers actively used technology as part of their teaching practice. One teacher described how he advised students to visit online educational sites on topics related to what he had taught in class. None of the teachers had received formal training in how to develop learning systems. Only three of the eight teachers had elementary knowledge of computers use.

In relation to teaching and learning, each teacher had different practices which were influenced by the grade of class they were teaching and the subjects they taught. Teachers who were teaching the final high school grades (grades 11 and 12)

carried out fewer activities, while those teaching the earlier grades (9 – 10) carried out more activities. The decisions of how to impart learning were also influenced by the pressure on the teachers of the higher grades to complete the curriculum in time, so prompting fewer classroom activities. There was a general practice which all teachers used frequently to teach and support learning in classroom environments.

1. The teachers would introduce topics by giving learners notes on white boards or chalk boards in the classroom. All of the participating teachers frequently used this teaching method and felt that learners benefitted by taking down notes and asking them questions.
2. Teachers also gave learners the opportunity to explore a learning topic and find out more about it. When asked which sources they expected the learners to use to acquire this information, the teachers cited class textbooks, books in the local library (for schools which were close to a library), newspaper editions which provided learning material, the Internet and minid videos (YouTube videos dedicated to mathematics lessons) amongst other sources. These teachers wanted the learners to reflect on the subject content before they were taught, so being able to link the information they had found on the topic with what the teacher was providing and their own personal reflection or understanding.
3. The teachers provided learners with class quizzes to evaluate their understanding of what they had been taught.
4. The teachers provided learners with examinations that graded their performances throughout the year to establish their understanding on the subject and allow them to understand and memorise their learning content.
5. Some teachers gave learners activities which required them to collaborate and prepare presentations on a learning topic.

In the framework we propose supporting the afore-mentioned learning activities through the use of a mobile learning process. We propose establishing the teaching and learning objective in section 8.3 and answering the questions of what is to be learnt, how it will be learnt and why will it be learnt in section 8.6. We then propose the use of traditional learning theories in section 8.8 to support the development process in answering these questions. The framework suggests behaviourist, constructivist, and cognitivist approaches of system design. Through drill related activities such as class quizzes learners would be supported through the behaviourist approach; in the constructivist approach, learners would be supported through providing them with sources such as class notes and worked examples of class exercise support them in creating knowledge; and finally when establishing how learners create or reflect on knowledge through the cognitivist theory, class tests related to a particular area in their subject can be used to explore how learners create their knowledge. These learning activities can thus be supported through appropriate mobile learning content development.

All teachers were aware of the different learning theories and could relate to them based on the approaches in which they conducted their daily lessons. Based on the framework in section 8.8, when mapping out how each theory could be used to support a mobile learning activity, teachers further suggested that learning theories should act as a support to the teaching and learning objective and should not be used as the primary pedagogy development approach. While all the teachers welcomed this approach and felt that systems developed in this way would support their teaching and support the learners equally, they felt that their lesson plans would also have to be developed in consideration of the use of technology. They further suggested that teachers should be trained to enable them to weave mobile learning effectively into their teaching plan as most of them did not have the experience of teaching fluently while relying on mobile or any form of technology to

support the process. In the framework we recommend in section 8.3 of the system development process that the design process be performed in active collaboration with the teachers to provide the systems with the element of pedagogical design. The systems should also be designed to support current practice rather than insisting on new teaching and learning methods, and so avoiding delays in their adoption and classroom use.

When asked why they did not use technology to support their current classroom practice the teachers cited various reasons. Teacher 1 explained that, “It is very difficult to stick to a lesson plan and a curriculum while using technology to teach.” Some of the participating teachers felt that the use of technology would only delay them in achieving their teaching objectives for the day. It seemed that, rather than supporting their current teaching practice, the teachers felt that mobile learning technology would mean more work for them.

Nonetheless, they felt that for the learners, technology would enhance their learning process. Teacher 2 reflected that, “the problem is that we’re not taught how to use technology to support learners in their learning process when we study for our degrees. Our reluctant perspective will often be influenced by our lack of experience in seeing exactly how technology would benefit my class without meaning that I have to spend extra effort in using it. The challenge is that we have to complete a curriculum deadline especially in secondary schools, and thus that’s all that occupies us”.

The teachers also suggested that an approach wherein they developed mobile learning systems with computer scientists would work as long as they did not have to do any further work on the system; that is, after the content was updated at the beginning of each term.

9.3.4 Using mobile learning systems to support the learning process and code-switching in formal and informal contexts

Under this theme we made recommendations based on the M-Thuto systems to the teachers of how mobile learning content and activities could be used to support both mobile learning and code-switching based on the learning context. We then evaluated their perspectives.

In the framework, we propose that oral and written activities should be tailored to support the change in code-switching in view of the fact that learner's code-switching will be different in both environments. In formal environments, code-switching will be related to the languages used in school and will be used less frequently. Formal environments can thus be supported through a steady presentation of content presenting content through the three names approaches of introducing content, reformulation and translation. This can be supported through activities such as class notes, class quizzes and class exercises. For informal learning, the activities should be determined in accordance with their capacity to support the constant code-switching that occurs during learning. Activities such as voice note-taking are recommended, being that they do not regulate the manner in which learners' code-switch while giving learners an active participation in their learning.

Teachers were in favour of formal code-switching support but cautioned against the activities selected for informal learning in their capacity for consistent code-switching. The teachers acknowledged that, while code-switching occurs frequently in informal learning environments, there should be regulation of how learners use it even in informal learning. They feared that learners would use slang instead of formal language in activities such as voice note-taking.

An evaluation then took place of how the framework measured up against current practice and how practice could be supported through mobile learning with the code-switching differing in accordance with the learning context. At this stage, the teachers were provided with different system interfaces of the M-Thuto mobile learning system, those which support formal and informal learning. The teachers were subsequently asked various questions about in what way they would use these systems to support a student's current learning process considering what the system offers and, most importantly, whether they would actually use the systems in their teaching process. We thus evaluated the potential viability of the systems to be developed following the same path proposed by the framework to support learners. This process of evaluation was conducted using different scenarios.

Scenario 1

You are teaching in classroom. A mobile learning system has been designed to support the learners providing them with class notes, class exercises and a quiz to enable them to learn. The content is presented using different languages in class. When would you use the system to support the learning process in class focusing on language and pedagogical support to learners?

Formal learning support system:

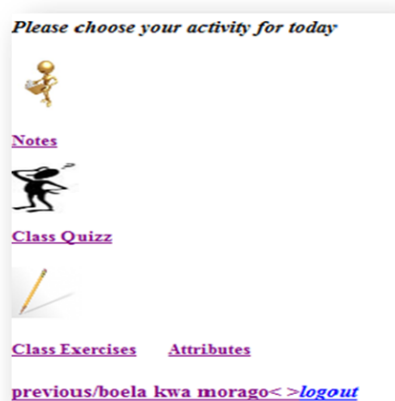


Figure 9. 2 Interface for formal mobile learning system

The teachers were presented with the interface illustrated in Figure 9.2, presenting the type of system which would be used to support formal learning. The teachers were less concerned with how and when the system would support the code-switching nature of learners, as they found it to be essential in any learning environment. The class exercises which provided solutions to learners and quiz support activities provided were thought to be most favourable for the learning system. For the class exercises, most of the teachers felt that, when introducing topics to learners, they would apportion class time for learners to tackle the different class exercises and check the worked solutions. Teacher 5 said, "In this way the learners would also be able to work together and practice the different exercises. This would also allow me to monitor what they had learnt also based on the questions they ask me related to what the system presents." Teacher 3 suggested that, "This would be helpful if the system was designed at the beginning of the academic year as I can plan on the topics and related exercises. I would then refer the learners to the class exercises after teaching them on the topic."

The teachers explained that the quiz results would save them time in having to review the results manually as they would otherwise have consolidated the results presented from the system. There were inconsistent views on the class notes. They acknowledged that they saved the learners the time they would otherwise have spent writing notes so allowing them to focus their listening more on what was being taught. However, they also felt that the notes would often be best used for informal learning and not during class so as to give learners more time to focus on the class exercises and quizzes. Other teachers found the class notes to be effective in enabling them to teach while simultaneously taking questions from learners because students did not need to focus on taking down all the notes down before the lessons ended.

Informal learning support system



Figure 9. 3 Interface for informal mobile learning system

When asked about the informal learning support, the teachers were provided with the interface presented in Figure 9.3. The teachers were first asked for their perspectives on the support that the proposed systems could provide in supporting learners in informal learning environments. Five teachers welcome chatroom learning as it gave the learners more freedom in experiencing their problems. The remaining teachers cautioned the uncontrolled use of language which can sometimes hinder the understanding of the teachers as learners tend to be more relaxed with the use of language when learning in informal spaces. All of the teachers approved of activities such as voice note-taking, citing the system's ability to provide them with consolidated work or notes from learners through which they could then monitor all of the learners' performances and thus monitor their understanding. All the teachers supported the notion of robust learning activities which engaged learners within informal environments, even if some teachers cautioned against the informal learning systems providing learners with too much freedom for language-switching.

The framework proposes systems which do not regulate the number of times learners' code-switch while learning informally. When asked about language interactions to support informal learning process using informal chatrooms, Teacher 4 stated, "While I do not support frequent code-switching I do feel that it enables learners to unreservedly explore content in an unregulated learning environment." The teachers also suggested that the system presented in formal classroom learning would be usable and effective even for informal learning. It would also be suitable for supporting informal learning because it enabled learners to continue learning outside the classroom, including at home.

9.4 Discussion

9.4.1 Validating the study against the framework

- Relevance of multilingual support in the mobile learning process

In the framework we explain the importance of understanding the learning context, the regulations governing the use of languages in schools and reaching a decision on whether multilingual learning should be used to support learning in schools. In the evaluation study we established that, while multilingual learning was not allowed in some multilingual schools, all of the participating teachers highlighted the challenges of teaching multilingual learners. Some teachers who could communicate in native languages were at times forced to resort to their native languages using code-switching to support learning.

The relevance of multilingual mobile learning support was also highlighted with the teachers reflecting on regulations affecting the use of languages in school teaching. In non-multiracial schools, the use of multiple languages was common amongst teachers and the schools did not have any firm policy that would obstruct

multilingual teaching and learning support. Such positive school management approaches validated the relevance of providing multilingual support in the mobile learning process, especially when considering that schools in the area were attended by multilingual learners with most of the participating teachers using more than one language to support the teaching and learning process.

In the proposed framework, we describe the importance of understanding the context of learning in order to be aware of the languages used within a specific geographic location and the language of learning and teaching. Even though in this study the government allows the use of native languages with English, multiracial schools have their own perspective on how languages are used for learning. Nonetheless, the results of the validation process demonstrated that different schools had different rules on how languages were used in schools. The creation of learning content to support multilingual learners required the use of languages permitted by the schools and conforming to the rules governing education.

An understanding of the native languages used for communication in teaching and learning allows the developer to also narrow down the languages used, being that in the evaluation study all language speakers commonly used Setswana. In instances where there were not a sufficient number of translators, the translator would only produce content available in, for example, English and Setswana, so being restricted to supporting learners from the Setswana speaking group. This evaluation process validated our approach to understanding the roles of different players in the process especially when focusing on language, the learners, the teachers and the context of learning as described in section 8.2.

- Supporting code-switching in formal and informal learning

In section 8.7 we introduce the three principal techniques of supporting written code-switching support. In the framework evaluation we established how teachers use code-switching in classrooms. We then enquired into how practical they found the approaches proposed by the framework in supporting learners who code-switch. In the evaluation study, the teachers validated the use of techniques for introducing and reinforcing content as the most important features of the system presented to support the switching process. None of the teachers had ever used direct translation as a means of supporting code-switching. In the framework, we propose translation as an alternative method which cannot be used in isolation to the afore-mentioned approaches of introducing content and reinforcing content.

- Supporting current teaching and learning practice through mobile learning

In the framework we established the current approach to teaching and learning. We then mapped out the traditional teaching and learning approaches which all the teachers currently use in providing learning. In the framework in section 8.7 and 8.8 we suggested approaches to providing learning content and activities through the use of traditional learning theories. The teachers validated this approach as they were already using traditional approaches to provide learning support. They further reflected that they would use technology if it enhanced the learning process and their teaching process. It was also important to note that teachers were not using novel approaches to teaching, with most preferring to stick to the methods that were traditionally used. They also raised interesting issues concerning the regulation of the content that learners could access on their mobile devices, claiming they would also struggle with the discipline of learners uniquely using the devices in the classroom, especially in formal environments.

In section 4.4 and section 5.4 we developed learning systems in collaboration with teachers to support their teaching plan. The objective was to establish how we could support the learning process by embedding the teacher's perspectives on obtaining the teaching and learning objectives. In section 8.2, 8.6, 8.7, 8.8 and 8.9 of the proposed framework we underline the importance of involving teachers in the definition of the learning content and the activities to be used in the learning process.

While the teachers validated the importance of this approach which the framework had suggested, they underlined the need for teacher training in using education technology in classroom learning because most of them had not had formal training. They also suggested that systems should be pre-developed at the beginning of term so that updates would not be needed during the term. The teachers did not want to have the responsibility of maintaining the systems – a validation of our argument in section 3.7 that it is inappropriate to provide teachers with systems that will require their continuous technical support as they end up not using the system. Teachers would be reluctant to use systems that would appear to add more work to their schedules and this would discourage them from viewing the technology as a way of supporting the teaching and learning process.

- Using mobile learning systems to support the learning process and code-switching in formal and informal contexts

The teachers supported the different learning activities for both formal and informal learning by providing learners with notes, mobile quizzes, with class exercises, voice note activities and chatroom access. They highlighted the importance of these approaches in reducing the amount of time learners use to take down notes and

giving them access to mobile digital notes and class exercises. The teachers believed that the system would also enable interactions amongst learners especially in the chatroom environments. The system would also reduce the time teachers spend marking and monitoring learners' performances using paper resources as they would have access to the digital results of mobile quizzes and digital voice notes. While the suggested approaches were based on the learning context, the teachers agreed that the activities could be used interchangeably in both formal and informal contexts.

When approaching language support for formal learning, the teachers expressed support for the three afore-mentioned approaches to content presentation. They were cautious about the challenges of learner discipline in using mobile devices, especially in formal classroom environments. An important issue was raised in regard to regulating the time during which mobile phones could be used or regulating the learning portals that to which learners would have access in a formal learning environment.

Different approaches could also be employed which provide mobile devices that were restricted for learning purposes; that is, defining the material that learners could access through the devices. In regard to using different code-switching practices according to the learning context, the teachers cautioned against the use of continuous code-switching in informal environments. They agreed on the importance of providing open platforms such as audio notes and chatrooms exclusively for informal learning. The rationale of the teachers here was that they wanted learners to improve their English language while only using their native languages to obtain an in-depth understanding of content.

9.4.2 Summary

The concept of mobile learning was novel to the participating teachers. While some teachers cautioned the use of technology to support learning, citing the regulation of language use and the content that learners would access when using mobile devices for learning in formal learning, there was a consensus in favour of guidelines provided by the framework to assist the development of mobile learning technology to support code-switching learners. The teachers already used code-switching as a classroom practice and so most of them welcomed the mobile learning support. Teachers found the support of language vital as it allowed learners to receive learning content which was tailored to support their unique situation.

The use of mobile learning to support learners was widely accepted by teachers with the condition that the design process should not require them to do any form of technical work. The teachers welcomed any new system that would support them on condition that it was pre-planned before the start of the academic year with the design process taking place before teaching began. They wanted the mobile learning systems to have the same function as the workbooks that learners were already using i.e. one which provided support for all areas of learning and one which did not require them as teachers to constantly update or maintain the systems.

The teachers also expressed a need for formal training in the use of the mobile technology with the hope of being able to ensure seamless learning in both the formal and informal learning environment. After understanding the perspectives of the teachers on the framework and their role in the design process, the teachers warmed to the role of mobile ICT in the classroom. Understanding that, in supporting learning through mobile learning systems, their role was to provide

pedagogy rather than technical design expertise to a multilingual mobile learning system.

Considering the trouble that some of the teachers usually experienced with learners bringing mobile phones to school (even if they were otherwise banned), the teachers remained positive in viewing the mobile phones as viable mobile learning tools. They felt that it would not be difficult to support the students in their learning process being that some of them were already bringing the devices to school. As experts in pedagogical design perspectives, the teachers were able to align the framework recommendations with current practice to assure that the introduction of new technology would not mean additional work for them.

9.5 Users evaluation – The students perspectives

In this section we evaluate students as users of the system. It was first important to introduce the background of the users, being that these participants represented a different context to teachers in the previous studies outlined in Chapter 4 and 5 and in Section 9.3.

9.5.1 The context of the participating students

Participating students were chosen based on the fact that they came from China, with China providing a code-switching context as a bilingual country actively using technology in education. While most of the participants came from private or non-governmental learning institutions, participants were able to provide their perspectives on the framework.

In China code-switching was mostly only limited to lessons where students were learning English while in all other lessons, Chinese would be used as the standard language of teaching and learning. The participating students revealed that, in state

schools, the teachers would switch between Chinese and English to teach, while learners also code-switched amongst themselves and with the teacher during the learning process. In private schools students could not code-switch because teachers only spoke English. Instead they code-switched amongst themselves for informal talk, assisting each other with learning content when they struggled to understand as a result of the language.

All the participants owned mobile phones and went to schools which had computers within the school premises for the purpose of learning. All of the participating students had experience of using mobile and electronic learning tools. The participants were provided with a lot of learning content in both digital and non-digital format designed to support bilingual learners even though the design was not targeted to support code-switching. However, eight participants complained about the poor translation techniques often used to present learning content, especially content for informal learning processes. The participating students explained that they were able to determine whether learning content presented in either books or electronic learning was initially created in two different languages or was translated from one language to the other. They also complained about the poor translation outputs of learning systems.

The results from understanding this context validated the importance of the understanding the different role players which we describe in section 8.1. As they affect every element of a mobile learning system. In this context there was a universal access of mobile phones and access by students to other advances mobile learning devices, this created room for more advanced systems to be tailored to support this learning context as the platforms could cope with the developed systems.

In this evaluation process students were provided with questions and scenarios which involved the use of mobile systems to support their bilingual learning process. These scenarios which were drawn from the principles of the framework. The student's responses were evaluated against the proposed features of the framework design. In each discussion, the findings were related back to the principles of the framework. The discussion here is divided into formal learning and informal learning evaluation. All responses are based on the students' high school learning experience.

9.5.2 Using a multilingual mobile learning system to support formal learning

Question- *Please explain how the following electronic activities have been used to support your learning in formal environments. Mention the activities that had already been used to support learning through mobile or electronic devices. Please describe how language was used to support the electronic systems.*

<i>Activity</i>	<i>Software</i>
Reading content	Mobile books
Assessment	Mobile quiz
Review / practice	Mobile worked class exercises

Table 9. 3 Supporting learning through mobile technology

The framework in section 8.6 proposes the use of similar mobile learning components in a mobile learning system as in table 9.3 to support the different learning activities based on the learning objectives. It was important to note that based on the below responses, there was a much higher use of the above

approaches through electronic learning and traditional text books as oppose learning using mobile learning platforms.

Most of the participants reflected upon the fact that much of the mobile learning technology they had used involved gaming technology in the form of mobile games. However, most of the games were not directly related to what they were taught. All of the students mentioned that their teachers did not tailor learning activities to support any form of mobile and electronic learning. Any electronic form of learning instead proved an additional option for the students, citing digital books accessible online, educational websites and other free-to-use open resources which they mostly used in their informal environments.

However, all of the students were much more knowledgeable about existing mobile and electronic devices and software which could support their learning, in contrast to the learners who participated in the studies in Chapters 4 and 5. This difference was perhaps a reflection on the difference in participants' backgrounds. It was very apparent that teachers in South African schools also did not commonly use mobile or electronic learning devices to support learners. The student's use of technology to support their learning mainly came from their own initiatives.

The students reflected that, in terms of supporting code-switching, the games used were available in both English and Chinese to convey the same content. Many of participants complained about the poor quality of translation, noting that it was very apparent that the game was originally written in English, for example, and later translated to Chinese. Student 1 reflected that, "As a native Chinese speaker and a second language English speaker I can easily tell which language the content was first created in and that it was translated." In their ability to identify when content was translated, some participants reflected that they had lost interest in what was

being presented because they had spent more time correcting the new version of the content.

Scenario – Introducing bilingual content to support mobile learning views

You are in a classroom where you are able to use a mobile learning system as part of the classroom learning process. The system enables you to access learning content. Which of the following paragraphs would you prefer to use to learn a new concept in class (introduction of content), reaffirm what you have been taught (reinforcement), or for the translation of content (translation)?

Colum A: English	Column B: Chinese	Column C: English and Chinese
The capital of China is Beijing. It is the second largest city after Shanghai. In China you can find great tourists attractions and a rich cultural history.	北京是中国的首都。它是第二大城市，仅次于上海。 在中国，你可以发现非常棒的旅游景点以及丰富的历史文化。	The capital of China is Beijing. It is the second largest city after Shanghai. 北京是中国的首都。它是第二大城市，仅次于上海。 In China you can find great tourist's attractions and a rich cultural history. 在中国，你可以发现非常棒的旅游景点以及丰富的历史文化。

Table 9. 4 Supporting code-switching through bilingual content

While students were not familiar with the term ‘code-switching’, the participants provided interesting results. These columns were set out based on the principles proposed by the framework which suggests the above presentation method in section 8.6 when supporting code-switching. Their responses to this question

presented the difference in learning objectives when using the code-switching practice. Column A and column B of Table 9.4 were the most commonly chosen paragraphs, with students citing that they would use both sections in their learning process both to introduce content (learn new content) and reaffirm content (reformulation). Column C was least preferred with only 4 participants selecting it.

The most common reasons provided for using column A and B was that students were only able to reflect on the contents of the topic after reading a lot of content. Participant A highlighted that, "I first read content in my home language and later read it in English after completing a paragraph or a page." For column C, students reflected that it was a good way of learning the English language and not necessarily for understanding the learning content. Ten of the participating students reflected that they would use column C when given a learning task in order to understand the task at hand. Most of the participating learners reflected that they would use both column A and B to understand a new concept. Many students reflected that they would start with column A then confirm what they read in column B. Other reasons were also given for their selection, with three students saying they would use column A with the aim of improving their English language skills and not necessarily for initial understanding and interpretation.

The framework presents the first and second columns as good ways of introducing content, while column three was used to reaffirm what was already mentioned in English. From this study it was clear that students found the long presentation of content in one language followed by the same content in another language to be effective in learning new concepts. Most learners were in agreement with the framework in viewing the final column as a way of reaffirming what they had initially read using only one language. When provided with an example of direct translation, seven students expressed their dislike for it, stemming from their disappointing

experience of direct translation. The remaining eight students felt that it was an alternative way to help them learn the second language effectively. It was important to note how, unlike learners in Chapter 4 and 5, code-switching was viewed more of a way of supporting students in their study of the English language.

The learners were also asked how they use code-switching in class to support their learning process. Most of the participants' reflected that they often asked friends whom they believed to be good at English to explain to them what the content meant. Alternatively they used dictionaries to find alternative word meanings as another means of understanding the content.

9.5.3 Using a multilingual mobile learning system to support informal learning

Scenario 3 – Current language and learning support in relation to the proposed multilingual mobile learning support

You are presented with an informal mobile learning portal which allows you to access a learning system that supports your learning process outside of school or in your informal environment. In reference to Figure 9.4, how do you currently learn using mobile or electronic devices? How do you currently learn in informal environments using different languages?

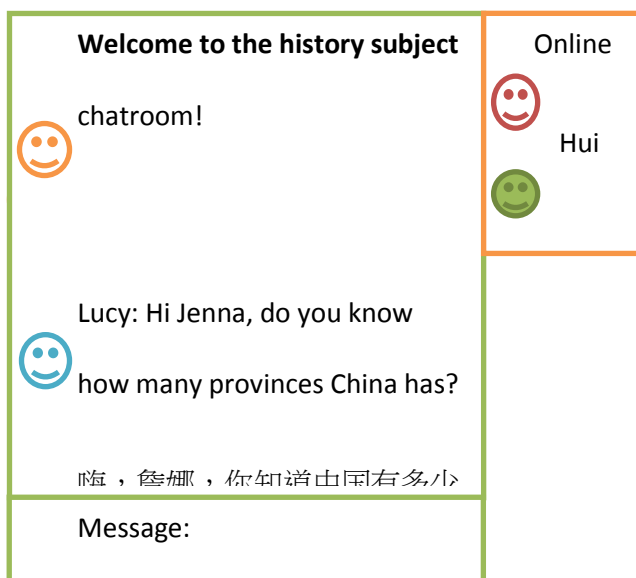


Figure 9. 4 Informal mobile learning

Our framework proposes that mobile learning be used to support informal learning through learning activities which engage learners while giving them freedom to code-switch. All of the participants admitted that they use their native language for informal learning, with minimal use of English. They only used English when reading and writing content or performing tasks that required the specific use of the English language. Nonetheless, different perspectives emerged when the participants discussing the current use of mobile devices or electronic devices to support informal learning processes. In addition, the students were presented with a system similar to that of Figure 9.4.

While the students were not formally given access to any mobile or electronic learning support software, they had taken it upon themselves to seek out informal learning material. Once again, these resources ranged from electronic learning games, which were translated from Chinese to English, to online videos which were also available to view in two languages. These were the main cited forms of electronic learning which eleven students had already used to support their informal learning.

All of the students actively used chatrooms for additional informal learning support, similar to the one displayed in Figure 9.4. The students mainly used these systems to help them understand concepts which they had acquired in the classroom environment. For informal learning, the framework proposed activities such as voice notes that students could create and upload to a system in order to keep track of their learning. Online educational chatrooms also enabled learners to communicate with each other. The informal nature of these approaches enabled students to use the languages with which they felt comfortable, without regulating the number of times they switched between languages. Although students were not required to use any dedicated electronic and mobile learning systems to support their informal learning, they personally sought out electronic learning activities to support their informal learning process much as they had done for the framework proposals.

Scenario 4 – Introducing bilingual mobile learning activities to support informal learning.

You are presented with an informal mobile learning portal which allows you to access a learning system which supports your learning process outside of school or in your informal environment. Which of these methods would you find effective in supporting your informal learning process?

<i>Activity</i>	<i>Software</i>
Keep track of class notes and help yourself to interpret and understand the content you have created	Voice notes: Create notes through mobile device application and upload them onto a dedicated mobile learning website
Discuss class notes and tasks with fellow students or with the teacher	Chatroom: Discuss critical learning factors in dedicated chatrooms which allow freedom of language.

Table 9. 5 The informal mobile learning activities

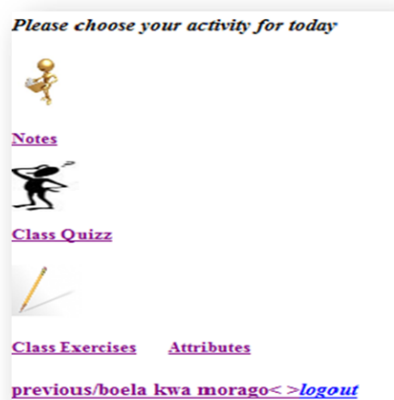


Figure 9. 5 The formal learning activities

The students differing preferences seemed to be influenced by their experience, being that for every activity they gave their opinion on why they preferred that method. The most popular electronic method cited by the students remained text-based activities with all participants preferring text-based learning as they had more

experience in this area. All of the students were of the opinion that figure 9.5 remained their preferred form of learning, even for informal learning. The students had used downloaded electronic notes but had never received electronic notes from their teachers. Hence all of their learning experience was principally based upon the traditional method of writing down notes.

In the framework we present the text-based activities used to support formal learning, while for informal learning we present audio-based exercises and chatroom-based learning to support multilingual as well as informal learning.

Being that these learners were first year university students who had just finished high school in China, they also had views on using electronic notes. All of them were open to using these notes on their mobile devices and some of them had already used their mobile ipads to download these notes. Some of these students explained that text-based learning kept them 'awake' and helped them concentrate because they had to stay focused on the learning content regardless of other distractions.

In reference to the activities presented in Table 9.5, only 5 students preferred audio learning in informal environments, stating that audio-based learning activities are not very engaging. Only one participant had experience of learning using an audio-based activity; the other students had no experience. Five of the participating students had previously used desktop-based video clips for learning during their high school years. None of them had used mobile videos or desktop-based videos on their mobile devices in high school. The video clips used by the other five participants often contained activities related to language learning lessons.

Another activity was added over the course of these interviews. This was the mobile gaming activity. Most of the participants had used a number of mobile phone games

and chatrooms for learning. Most of the participants had used and enjoyed this type of learning activity to support their informal learning.

In addition, as presented in table 9.5, all of the students favoured chatrooms as a learning approach. However, for the activities outlined above it is important to note once again that students felt that they would use their Chinese more frequently in informal learning, especially in the chatroom environments.

9.6 Discussion

9.6.1 Validating the study against the framework

- Using a multilingual mobile learning system to support formal learning

In the study the participants reflected on their background of using the mobile and electronic learning which was available to support multilingual learners. While each student was aware of the different electronic learning support platforms, most these students used traditional textbook and electronic learning platforms to support their learning. In the framework we propose that mobile learning should be supported through learning objectives in section 8.6. Students cited websites, electronic videos as some of the main resources that they used to support their learning. Most of them did not use electronic learning to support their high school education as the teachers did not provide these platforms for them.

The participants reflected upon the fact that most of the existing technology was not tailored to support code-switching. Instead it was tailored to support the multilingual reception of learning content. The framework suggested that it was important to support multilingual content presentation using the different approaches outlined in sections 8.6 and 8.8. The students also reflected upon how they easily picked up poor translation of content, which often deterred them from concentrating on the content being that they were left focusing on the poor language use. In the

framework we underline the importance of having language specialist take part in the process of designing the system so as to enable the initial development of learning content in multiple languages.

The students were questioned about the different situations in which they would use the proposed methods of supporting code-switching while learning (introducing content: Column A and B of table 9.4; reinforcement: column C of table 9.4; and translation), especially in classroom learning. They preferred the first two approaches expressed in the three columns, taking the view that they were the most effective in supporting their code-switching approach. Once the concept of direct translation was explained to them, the students were of the opinion that it was their least desired approach, due to their prior experience of translated learning content. The framework presents these methods as the most effective and although direct translation is supplied as an option, we can conclude that it is best used where the availability is scarce of human language translator resources to support learners.

However, the learning context did not play a significant role in the way they preferred to use the code-switching support. As the framework outlines, although the content presentation approaches can be used based on the context of learning, learners are able to use the content both in formal and informal learning.

- Using a multilingual mobile learning system to support informal learning

In the informal learning environment, students testified that they had no experience of informal learning mobile applications dedicated to supporting code-switching. The students also claimed that they used different forms of electronic learning which provided content in two languages and those not necessarily dedicated to code-switching. The framework proposed both chatrooms and activities such as voice note-taking (Section 9.3.5) to support informal mobile learning. In line with the proposals made in the framework, the students reflected that in informal spaces

they preferred more engaging approaches to learning which did not limit their language use. It was also important to connect these conclusions to the teachers' evaluation study in Section 9.4.1. The teachers had cautioned against giving too much freedom to learners in informal mobile learning systems in the support of constant code-switching. Even though the teachers suggested that boundaries could be put in place, students would always use their home languages more frequently to support informal learning.

When validating the suggestions in the framework of learning activities which could support learning and code-switching in informal environments, the students presented a different perspective. While they found the chatroom environments effective in supporting both informal learning and code-switching, audio-based activities were not viewed as the most effective way of engaging learners in informal learning. The suggestion here is that more text-based learning approaches can still be used for informal learning support because students still prefer them in informal environments to support both code-switching and informal learning.

9.6.2 Summary

While the participants provided both expert perspectives and the views of potential users/students on the systems, it was clear that the participants in the studies mostly came from a context where technology (mobile and situational) was not actively used to support the process of formal or classroom learning. The users were able to supply us with important considerations that were mostly aligned with the framework proposal.

The main concern for the participants was that many teachers worried more about the curriculum being followed successfully than using the technology to aid learners' reception of the curriculum. The objective of the mobile learning systems was to aid the learning process, which is something that they would need to understand during

the development process of a mobile learning system. When it came to perspectives on how code-switching could be supported for optimal language reception, the teachers' point of view differed. However, it was important to note that while the teachers did not actively use written form of content to support code-switching, they already used oral methods to support it. The general consensus amongst teachers was that any form of language support given to the learners was crucial to enhancing their learning process.

Taking the users' perspective, although the learners were more exposed to technology and had access to different forms of technology, we saw that the participating students took similar positions to the participants in Chapters 4 and 5 in relation to gaming approaches. Students found gaming to be a good method of supporting mobile learning. While the students were not provided with technology specifically dedicated to the support of code-switching, a lot of technology in their country was developed for the use of two languages in aiding their learning process. The participants found this to be an important part of their learning process because they were always presented with options on how to view learning content. The participants also presented rich data in regard to their use of personal initiatives to seek learning support technology. The conclusion can be drawn that both mobile and situated technology has the potential to support learning if learners are given both access and the appropriate infrastructure to support the learning process.

9.7 Improvements

From the experts' perspective which builds on the framework perspectives, we found that certain elements of teacher training could form part of the system design process. The provision of training for teachers to use the technology, or at least a support manual when the developers had finished the project was an additional principle that would aid teachers in using the system to support learners in the new

process. We also found that it was important to regulate the learning devices of the learners so as to avoid them going into websites which were not related to their learning process.

From the users' perspective, gaming was viewed as an important approach that would be highly effective in supporting the informal learning process. The students also reflected that text-based learning activities still formed an important part of informal learning that supported code-switching in informal environments. In Chapters 4, 5 and 9 participants emphasised the importance of gaming approaches for learning because they incentivised students to undertake further learning.

These perspectives constitute further modes of enhancing multilingual formal and informal mobile learning through the proposed framework.

9.10 Summary

This chapter presents two phases of evaluation of the proposed multilingual mobile learning framework. The chapter evaluates how the principles proposed by the framework were practical in supporting the learning process in both formal and informal environments. In the next chapter we reach the conclusions of the thesis, evaluating the contribution of this research to existing research and future work that could be undertaken in the same area of research.

This chapter presents the final conclusions of the thesis. The chapter evaluates the thesis development process, theories that emerged from the thesis and my contribution to the research area.

Chapter 10

Conclusion

10.1 Supporting the research questions

At the beginning of the research I reflected on my research motivation and provided research questions which emerged from the motivation. Three main research questions were established:

Question 1: How can mobile learning be used to support multilingual learners in their formal learning process?

Question 2: How can mobile learning be used to support multilingual learners in their informal learning process?

Answering the research questions these objectives were set out in the initial chapter:

- Establish how learning occurs in formal and informal environments and how learning resources are currently used to support this process;
- Identify the support that mobile devices can have through tailored software development in supporting learning content and activities by providing pedagogy approaches to the development process;
- Identify the process of code-switching and how learning content and activities supported through mobile learning can be tailored to support the process of code-switching.

This first question investigated the role that mobile devices can play in supporting current teaching and learning practices in under-resourced formal and informal learning. The focus of the question was to investigate how learning occurs and the

role that mobile devices can have in improving the process of learning in multilingual environments. The questions also mainly investigated the important issues to be considered when designing a system to be used to support learners who code-switch while learning.

In chapter 4 and 5 we investigated the process of teaching and learning in formal and informal multilingual high school environments. Considering the current teaching and learning practice we formulated a mobile learning application called M-Thuto that was developed with the teachers and language specialists, providing learners with learning support while providing them with multilingual learning resources. The system was also based on a teaching and learning approach that supports a code-switching mobile learner. The system was developed to provide learners with the resources that were needed to support them in achieving the learning activities provided by their teachers. Data were then collected to evaluate the characteristics that should be considered when designing a mobile learning system to support a code-switching learner by monitoring the success of M-Thuto in providing relevant support in this context.

In chapter 6 we later evaluated existing automated human language translation processes that can be used to aid developing multilingual learning content which would be used in the mobile learning systems in the absences of human translators.

The main issues that are used to answer the first question stemming from the findings contributing to the framework were the following.

The process of learning is defined by learning objectives, the learning tools and the learning outcomes set out against the initial objectives. These objectives are defined by the teacher and the learner. The objectives can be supported through mobile devices through appropriate content and learning activity support. Learning theories are a traditional way of supporting learning which many teachers still use to support

learning in both formal and informal environments. We identified behaviourism, cognitivist approach and constructivism as main approaches that can be used to create learning activities. Mobile learning systems should thus be modelled around these traditional practices. Through the support of the teacher novel approaches can be used to support learning through the support of mobile devices, making the learning process accessible in any context. The approaches mentioned include providing mobile class notes for learners, providing mobile quizzes for learners, providing learning chatrooms for learners. Each activity can be mapped against a learning theory to achieve the teaching and learning objective. In the behaviourist theory learners can be provided with continuous mobile class quizzes to reinforce what they had learnt while allowing the teacher monitors their behaviour when answering the questions. For the constructivist approaches learners can be provided with topic areas and provided with mobile notes and worked examples, to explore further information on the learning content and be required to create and upload mobile audio clips reflecting on what they had understood about that learning area. For the cognitivist approach learners can be provided with dedicated notes and given questions to refer back on the knowledge they already gained to attempt the questions. The teacher in this sense monitors how the learners reflected on what they know to answer the new task. These are some of the approaches that can be used to support traditional theory through mobile learning.

Learning through a specific language affects the outlook of learners reaching their learning objective. The use of more than one language to support the learning process should be appropriately supported considering how learners and teachers using bilingual approaches to support learning and the languages used for learning in a specific school context. The approaches used by teachers and learners, for example the ones specified in section 8.7 play an immense role in presenting content to learners who code-switch. We outlined in the research how the

approaches of reformulating content from one language to another, introducing content using one language and later showing the same content in another language, and direct translation of content, are the main methods of supporting content view for multilingual mobile learners. The presentations can be presented on mobile screens using examples in section 8.7.

Question 3: How can a mobile learning framework be used to develop mobile learning systems that support the learning process in multilingual learning environments?

Answering the research question these objectives were set out in the initial chapter:

- Identify and support the approach in which teachers use to provide learning in both formal and informal multilingual environments
- Identify and support the process of learning for multilingual learners in formal and informal environments

The second research question sought to establish how these principles can be used to support developing mobile learning systems:

In this thesis we propose a framework that can be used to support the development of multilingual mobile learning systems. The framework is aimed at supporting mainly technology specialists who do not know the principles governing the learning environment. We presented important considerations which are education approaches that enable learner centred approaches. In the framework we began by investigating the different role players contributing to the process of learning which should be considered in the development of mobile learning systems. This is described in section 8.1. These role players mainly include the mobile learning teachers, the mobile learners, the language of instruction and the language of

learning as they may differ with context, the mobile devices focusing more specifically on mobile phones, and the learning context. We then defined how different learning content and activities can be supported through identifying the learning objective and using traditional learning theories to support this process as identified in section 8.6, 8.7, and 8.8. We reflected on how content can thus be presented through the system using three main approaches of presentation which are introduction of content, reformulation and translation. These methods were used as approaches which could support code-switching in the formal learning environment. We also introduced multilingual learning in informal environments by providing learners with portals that enable them to upload multilingual audio notes. These would not restrict learners to code-switching whilst allowing them the opportunity to learn. In all of the above mentioned support processes teachers can also be provided with access through systems to monitor the performance of learners providing them with feedback and support based on their challenges.

These basic principles can provide the needed pedagogical support that technology professionals need when developing mobile learning systems to be used in multilingual learning environments.

We later evaluated this framework in chapter 9. The evaluation process reflected that while systems can be used to provide the support necessary to facilitate the mobile learning process red tapes such as policies governing the process of mobile phones or devices in school should be considered as barriers on the mobile learning process. We also established that it is important to understand how different languages are used to support the process of learning in and out of school.

The evaluation process also revealed how learners view each language as some may have more value for one over the other; how learners use the process of code-switching to support their learning as some may have more use for it while others

mainly use one language more often in their learning and seldom use the other to support learning; we established different teachers ability or inability to use technology can affect the mobile learning process. These challenges should be realised and provided for at the beginning of the systems development process.

10.2 Research Contribution

The mobile learning area

Contribution

The mobile learning research area is a rapidly developing area. While there are many advances in supporting developers to create appropriate mobile learning technology, none so far has focused on supporting the learning process through focusing on human language that is used to facilitate learning in different subjects. The greatest contribution of this thesis was to show how mobile learning can support multilingual learning by also supporting the process of code-switching. Code-switching as defined earlier is the main behaviour which multilingual learners and teachers use to support the learning process by switching between languages to support learning. The contribution was made by showing how mobile learning systems using different techniques that include, navigation support through language views, language support tools which can be embedded into any system design in sections 8.5, 8.6, 8.7 and 8.8 and automated machine translation in section 6.1 and 6.8 which can be used to help the developer to translate learning content where translators are a scarce resource.

Limitation: While we established the type of support that can be used to support learners who code-switch in South Africa, the process of code-switching and how it is used in learning environments can differ with each country. In this research we were only able to provide a case using one country. With appropriate resources and

access to participants in schools, other multilingual countries can be used as case studies evaluating how code-switching is used in that country and how mobile learning can support multilingual learning considering that context.

Contribution

Through a framework we introduce issues to consider when developing software that supports high school learning. While there are many existing mobile learning frameworks as reflected in section 3.10 and section 7.9 none of them take a practical approach into showing the challenges and how to support developing software to be used in multilingual developing country high school environments. The contribution the research makes is supporting computer science specialist to understand how learning occurs in multilingual learning environments by defining in sections 8.2 the role players of a high school mobile learning ecosystem, section 8.3 and 8.4, Using traditional software development approaches to create a mobile learning systems, 8.7 and 8.8, using teaching and learning objectives supported by traditional learning theories to create mobile learning content to support different formal and informal learning activities, and finally the central aspect in section 8.5 8.9 and 8.10 using different content presentation methods to support the process of code-switching. While computer science specialists often possess programming skills, they often do not have the educational specialist knowledge. This thesis contributed to making the lives of programmers easier by supporting the pedagogy development theories of developing mobile learning software with specific support on high schools in developing countries.

Limitation: While in this research we are able to provide some ways of supporting different educational content through the use of the M-Thuto system which provided class notes support, class exercises and audio notes storage to support different learning activities through formal and informal learning, we did not provide enough

examples that can be exhausted by the use of a mobile device to support mobile learning. The restriction on the number of times case studies which can be conducted in schools limited our examples to those presented in this thesis in chapter 4 and 5. The framework also provides pedagogy support as oppose to software development support and assumes that developers will possess the relevant skills and programming to program multilingual mobile learning systems using the proposed framework.

The South African education environment contribution

Contribution

Currently the South African government is maintaining an equal language policy on teaching and learning in high schools. Even though English is the language of instruction teachers use more than one language to teach. The government has also introduced a policy to force all university students to learn a South African language as a course. This is in the light of promoting the use of South African languages.

There are currently no known electronic learning resources that can support the process of bilingual and multilingual learning in high schools. Existing resources are only available in English. This research makes a contribution of reflecting how the new area of mobile learning can be used to support learning supporting the call for the government to promote learning in native languages.

The South African government through the Department of Education has also rolled out a mobile learning program by providing learners in South African high schools with ipads and free Wi-Fi in schools (SouthAfricanInfo, 2013) .

This project has introduced a need for mobile learning software which is customised to support learning in schools. The framework described in this thesis is able to provide the development of mobile learning software to support the mobile learning process. The limit of the case study approach is that it only presents one developing country case study. With more resources, different developing country case studies can provide a wider outlook of pedagogical considerations.

10.3 Future work

The process of supporting multilingual users and learners in education technology is still in its infancy.

One of the main methods of providing learning material on mobile devices is through authoring tools. While this framework offers approaches that can be used to support learning through a “ready-made package” approach, an authoring tool can be researched on its ability to be tailored to support multilingual mobile learning delivery. This can be done by enabling different presentation techniques such as navigation to support code-switching and multilingual views.

In this research we mention different ways in which learning activities that can be built around traditional learning theories to support mobile learning in high schools. There is limited research that reflects on supporting traditional classroom and informal learning which still rely on traditional methods of teaching and learning. There is a need to further research on this by using different classroom and informal learning scenarios supported by mobile learning applications through traditional theories such as behaviourism and constructivism as teachers still use these methods to provide learning.

In this research we also proposed a method of translation in supporting multilingual content development. While there has been vast research on machine translation,

there has been no research on how translation techniques can be used in mobile learning technology to enable multilingual learners to have access to multilingual learning technology. Translation techniques such as rule based translation can be researched on how language support can be embedded into the developing process of learning software instead of relying on external standalone machine translation software.

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Appendix A – Questionnaires and interview guide for the studies presented in chapter 4

Consent Form

Name of Research: The development of a bilingual mobile learning framework to enhance learning material in South African high schools

Name of Researcher: Mmaki Elisabeth Jantjies from University of Warwick

Contact Details: M.E.Jantjies@warwick.ac.uk

Please note:

- Your participation in this research process is voluntary.
- You understand that the aim of the research is to see how the existing learning material available to learners in high schools can be improved to support your learning process.
- You can request a copy of the research findings at any time from the author
- Your name and identity will be protected and will not be revealed in the research. Therefore your participation in this research is anonymous.

I voluntarily agree to participate in this research.

With full knowledge that:

- The nature of the research and all its implications has been fully explained to me and I agree with them.
- I have been explained of my right to choice of participation and have been fully explained to, that this information will be treated confidentially and may be used for the purposes of publication.

Signed

Date.....

Questionnaire for: bilingual mobile learning in High schools

Please write the relevant answer next to the question on the provided space

(a) Biographical background

1. Learners name
2. Learners age
3. Learner's gender (please choose one of the following, ticking the appropriate option)
Male.....Female.....Will not disclose.....
4. Learners grade.....
5. Learners school name.....
6. Which of these languages can you communicate in? Tick in the appropriate boxes

	Speak	Read	Write
Setswana			
isiXhosa			
isiZulu			
SeSotho			
Sesotho sa Leboa			
siSwati			
Tshivenda			
Xitsonga			

7. What is your home language (it can be more than one)?

.....

Please place a tick next to the appropriate answer below

8. Does your teacher at times use other languages to try and explain a concept to you in class?

- (a) Once
- (b) More than once
- (c) Regularly

9. Which of these languages does she/he use other than English, Tick next to the correct answer?

- (a) Afrikaans
- (b) IsiNdebele
- (c) IsiXhosa
- (d) IsiZulu
- (e) Sesotho sa Leboa
- (f) Sesotho
- (g) Setswana
- (h) siSwati
- (i) Tshivenda
- (j) Xitsonga

10. Do you sometimes have difficulties in understanding the learning content as a result of the language it is presented in. For example if the class is only taught in English? Please explain the reason for your answer.

- (a) Yes
- (b) No

.....

.....

11. Do you think that being taught in English affects the time you take to understand your teacher?

- (a) Yes
- (b) No

12. Do you ever ask your teacher a question in class in another language other than English (do you code-switch while learning), if yes please explain which languages do you switch between?

- (a) Yes
- (b) No

.....

13. Do you ever code-switch while learning during lessons, if yes please explain which languages you use to code-switch?

- (a) Yes
- (b) No

.....

14. Do you ever use other languages other than English to reinterpret learning content, if yes which languages do you use?

- (a) Yes
- (b) No

.....

If your answer above was no move to question 14

15. How frequently do you use other languages to help you learn?

- (a) Frequently
- (b) Rarely
- (c) Occasionally

(b) Mobile technology background

Please tick next to your required choice

16. Does your school have computers for learning, if yes do you have access to use them.
If your answer is yes, provide the answer in the open space below explaining when you can do so?

- (a) Yes
- (b) No

.....

17. Do you own a mobile phone?

- (a) Yes
- (b) No

If yes, is it a

- (a) Contact
- (b) Prepaid

If your answer is no for the above question please proceed to go to question 20

18. What is the name of your mobile phone brand?
- (a) Samsung
 - (b) Nokia
 - (c) HTC
 - (d) Apple
 - (e) Other please specify
19. Does your phone have basic features that allow you to use the Internet?
- (a) Yes
 - (b) No
20. Have you ever interacted or played with a learning application or a learning game on your phone or anyone else's phone? If yes please specify if it was a game or application.
- (a) Yes
 - (b) No
-

If your answer is no for the above question please proceed to question 26

21. Was learning content related what you are taught at school?
- (a) Yes
 - (b) No
22. Was the content available in:
- (a) One language (please specify the language)
-
- (b) More than one (please specify the languages).....
23. Did you learn something related to your school work from the application or game?
- (a) Yes
 - (b) No
24. Did you find learning on a mobile phone (please provide a brief explanation below)?
- (a) Easy
 - (b) Difficult
-
-
25. Were the words on the screen:
- (a) Visible
 - (b) Not clear

26. Do your teachers ever give you homework or assignments that need you to use:
you can tick more than one choice
- (a) The Internet
 - (b) To type the assignment or homework on a computer
 - (c) All of the above
27. If you don't own a mobile phone do you have access to one at home? If yes can you access the Internet with it? Please explain in the space provided.
- (a) Yes
 - (b) No
-

(c) M-Thuto Learning Application

Please tick next to your choice

28. Did you experience any difficulties with input when using the keypad?
- (a) Yes with the keypad
 - (b) Yes the screen size was too small
 - (c) All of the above
 - (d) None of the above
29. Did you find any difficulties in seeing information on the mobile screen, please explain after selecting?
- (a) Yes
 - (b) No
-
-
-
30. Did you use the English or Setswana option to read the information?
- (a) English
 - (b) Setswana
 - (c) Both
31. Would you like to have more learning material available on your mobile phone?
- (a) Yes
 - (b) No
32. Would like to be able to communicate with your teacher on your mobile phone regarding concerns related to your school work?
- (a) Yes
 - (b) No

33. Did you find M-Thuto effective in supporting you to learn in class?

- (a) Yes
- (b) No

34. Did you find M-Thuto effective in supporting you to learn outside of the classroom?

- (c) Yes
- (d) No

35. Would having all your learning material available on your mobile phone motivate you to study? (please explain below)

- (a) Yes
- (b) No

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36. Do you feel that mobile material motivates them to learn regularly on their mobile phones? (please explain)

- (c) Yes
- (d) No

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.....

37. If you had to change M-Thuto to make it more helpful towards your studies what would you add or change:

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Learners Interviews

(a) Biographical Background

What are the learners following details:

1. Name
2. Age
3. Gender
4. Name of School

(b) Language history

5. What is your home language?
6. How many languages can you speak, write and read?
7. Has your teacher ever used more than one language to help you with your understanding (once, more than once, regularly)?
8. Do you ever code-switch while learning during class?
9. Do you find any difficulties at times your teacher when they are teaching?
10. Do you think it has anything to do with the language that you are being taught in?
11. If you were given a choice to be taught in more than one language would you accept it?
12. Would this include your home language?
13. Do you use English to communicate when working with your friends on your homework's or assignment? If not which language d you use and why?

(c) Technology Background

14. Do you have a phone? If yes what model? Is it contact or prepaid?
15. Do you have computers in school if yes when can you use them?
16. Which network are you using?
17. Is there any reason why you use this network?
18. Have you ever used a mobile learning game or application?
19. Does your school have computers? If yes do you have access to them?
20. Did you learn anything helpful from it? Related to your school work, or just general knowledge?
21. Was this on your phone?
22. Did you find any challenges with seeing on the screen and inputting on the keypad?
23. Does you teacher ever require you to use the Internet or the computer for your homework or assignment?

(d) M-Thuto experience

24. Did you choose the Setswana or English or both options when learning?
25. Would learning on a mobile phone motivate you to learn anywhere?
26. What did you find exciting about M-Thuto and what didn't you like about it?
27. What would you change about it?
28. Do you feel that having mobile learning material helps you to learn and beyond the classroom?
29. Would you enjoy being taught in more than one language?
30. If you were allowed to learn in more than one language and had books explaining content in more than one language what would the languages be?

Teaches Interview questions

(a)Background questions

1. Teachers Name
2. Name of School
3. Home language
4. Number of learner in his/her class?
5. What subjects do you teach
6. Do you have a multilingual class if yes largely populated by which languages?
7. Do you ever feel that learners do not understand your language when you teach?
8. Do you ever try to elaborate using another language?
9. Does it assist the learner in anyway when you explain using more than one language?

(b) Technology questions

10. Do you use technology to support learners in their learning process?
11. Do you use any technology to support your teaching process?
12. Does the school have a computer laboratory in place?
13. For what purpose do they utilize this laboratory?
14. Do you ever give learners homework that requires them to use a computer?
15. Do you ever use technology in any way to conduct lessons?
16. If not why don't you use technology to support your teaching process?
17. Do you find M-Thuto helpful to you as a teacher, if yes how?
18. Do you think it would help to improve the learner's current performance?
19. Would you add any other feature to it that would make your work more easier?

Appendix B – Questionnaires and interview guide for the studies presented in chapter 5

Questionnaire for: bilingual mobile learning in High schools

Please write the relevant answer next to the question on the provided space

(a) Biographical background

1. Learners name
2. Learners age
3. Learner's grade.....
4. Learners gender (please choose one of the following, ticking the appropriate option)
Male.....Female.....Will not disclose.....
5. Learners school name.....
6. Which of these languages can you communicate in? Tick in the appropriate boxes

	Speak	Read	Write
Setswana			
isiXhosa			
isiZulu			
SeSotho			
Sesotho sa Leboa			
siSwati			
Tshivenda			
Xitsonga			

7. What is your home language (it can be more than one)?

.....

8. Does your teacher at times use other languages to try and explain a concept to you in class?

- (a) Once
- (b) More than once
- (c) Regularly

9. Which of these languages does she/he use other than English, Tick next to the correct answer?

- (a) Afrikaans
- (b) IsiNdebele
- (c) IsiXhosa
- (d) IsiZulu
- (e) Sesotho sa Leboa
- (f) Sesotho
- (g) Setswana
- (h) siSwati
- (i) Tshivenda
- (j) Xitsonga

10. Do you sometimes have difficulties in understanding the lessons as a result of the language it is presented in. For example if the class is only taught in English? Please explain the reason for your answer.

- (a) Yes
- (b) No

.....

.....

11. Do you think that being taught in English affects the time you take to understand your teacher?

- (a) Yes
- (b) No

12. Do you ever ask your teacher a question in class in another language other than English (do you code-switching while learning), if yes please explain which language?

- (a) Yes.....

- (b) No
13. Do you ever use other languages other than English to reinterpret learning content, if yes which languages do you use?

- (a) Yes
- (b) No

If your answer above was no move to question 14

14. How frequently do you use other languages to help you learn?

- (a) Frequently
- (b) Rarely
- (c) Occasionally

(b) Mobile technology background

Please tick the relevant box next to the question in the provided space and explained when you are asked to do so.

15. Do you have a computer or access to one, if yes please explain below.

- (a) Yes
- (b) No

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16. Does your school have computers, if yes are you allowed to use them, please explain below.

- (a) Yes
- (b) No

.....

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17. Do you have a mobile phone, if no do you have access to one at home (please explain)?

- (a) Yes
- (b) No

If yes, is it a

- (a) Contact
- (b) Prepaid

If your answer is no for the above question please proceed to go to question 20

18. What is the name of your mobile phone brand?

- (a) Samsung
- (b) Nokia
- (c) HTC
- (d) Apple
- (e) Other please specify

19. Does your phone have basic features that allow you to use the Internet?

- (a) Yes
- (b) No

20. Have you ever interacted or played with a learning application or a learning game on your phone or anyone else's phone? If yes please name it the type of the phone.

- (a) Yes
- (b) No

If your answer is no for the above question please proceed to question 26

21. Was learning content related what you are taught at school?

- (a) Yes
- (b) No

22. Was the content available in:

- (a) One language (please specify the language)

.....

- (b) More than one (please specify the languages).....

23. Did you learn something related to your school work from the application or game?

- (a) Yes
- (b) No

24. Did you find learning on a mobile phone (please provide a brief explanation below)?

- (a) Easy
- (b) Difficult

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25. Were the words on the screen:

- (a) Visible
- (b) Not clear

26. Do your teachers ever give you homework or assignments that need you to use:
you can tick more than one choice

- (a) The Internet
- (b) To type the assignment or homework on a computer
- (c) All of the above

27. How often did you revise what you learnt during class?

- (a) Daily
- (b) Weekly
- (c) Fortnightly
- (d) Monthly

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(c) M-Thuto Learning Application

28. Did you experience any difficulties with input when using the keypad?

- (a) Yes with the keypad
- (b) Yes the screen size was too small
- (c) All of the above
- (d) None of the above

For the following questions please also provide a brief explanation of your choice.

29. Did you find any difficulties in seeing information on the mobile screen, please explain after selecting?

- (a) Yes
- (b) No

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30. Did you find any difficulties in using your mobile phone in creating the audio clip?

- (a) Yes
- (b) No

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31. Did you find any difficulties in uploading the clips (i.e. the Internet upload pace, experiencing difficulty with the system upload process)?

- (a) Yes
- (b) No

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32. Did you find any difficulties in retrieving your audio clips for learning?

- (a) Yes
- (b) No

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33. Which languages did you use to create your audio clips?

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34. Which of the following sources did you use to look for learning content to help you to create the content for the clips? Please explain the process you followed when doing this? (newspapers, the mobile phone Internet, your science workbook, your class notes and any other sources)

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.....

35. How often did you create the audio clips?

- (a) Daily
- (b) Weekly
- (c) Fortnightly
- (d) Monthly

.....

.....

.....

36. How often did you upload the audio clips?

- (a) Daily
- (b) Weekly
- (c) Fortnightly
- (d) Monthly

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37. How often did you revise using the audio clips?

- (a) Daily
- (b) Weekly
- (c) Fortnightly
- (d) Monthly

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38. Which of these platforms would you prefer to use in supporting you to learn in your informal environment?

- (a) Text- book
- (b) Audio clip
- (c) Both

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39. Did you find the M-Thuto learning process effective in helping you to learn in your informal environment?

- (a) Yes
- (b) No

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40. Would you like to have more learning material available on your mobile phone?

- (a) Yes
- (b) No

41. Would like to be able to communicate with your teacher on your mobile phone regarding concerns related to your school work?

- (a) Yes
- (b) No

42. Would having all your learning material available on your mobile phone motivate you to study anywhere outside the classroom? (please explain below)
- (a) Yes
 - (b) No

.....

43. If you had to change M-Thuto to make it more helpful towards your studies what would you add or change:

.....

.....

.....

.....

.....

Learners Interviews

(a) Biographical Background

1. Name
2. Age
3. Name of School

(b) Language history

4. What is your home language?
5. How many languages can you speak, write and read?
6. Has your teacher ever used more than one language to help you with your understanding (once, more than once, regularly)?
7. Do you find any difficulties at times your teacher when they are teaching?
8. Do you think it has anything to do with the language that you are being taught in?
9. If you were given a choice to be taught in more than one language would you accept it?
10. Would this include your home language?
11. Do you use English to communicate when working with your friends on your homework's or assignment? If not which language d you use and why?

(c) Technology Background

12. Do you have a phone? If yes what model? Is it contact or prepaid?
13. Which network are you using?
14. Is there any reason why you use this network?
15. Have you ever used a mobile learning game or application?
16. Did you learn anything helpful from it? Related to your school work, or just general knowledge?
17. Was this on your phone?
18. Did you find any challenges with seeing on the screen and inputting on the keypad?
19. Does you teacher ever require you to use the Internet or the computer for your homework or assignment?

(d) M-Thuto experience

20. Did you choose the Setswana or English or both options when learning?
21. Would learning on a mobile phone motivate you to learn anywhere?
22. What did you find exciting about M-Thuto and what didn't you like about it?
23. What would you change about it?
24. Would you enjoy being taught in more than one language?
25. If you were allowed to learn in more than one language and had books explaining content in more than one language what would the languages be?

Learners Interviews

(a) Biographical Background

1. Name
2. Age
3. Name of School

(b) Language history

4. What is your home language?
5. How many languages can you speak, write and read?
6. Has your teacher ever used more than one language to help you with your understanding (once, more than once, regularly)?
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(c) Technology Background

12. Do you have a phone? If yes what model? Is it contact or prepaid?
13. Which network are you using?
14. Is there any reason why you use this network?
15. Have you ever used a mobile learning game or application?
16. Did you learn anything helpful from it? Related to your school work, or just general knowledge?
17. Was this on your phone?
18. Did you find any challenges with seeing on the screen and inputting on the keypad?
19. Does you teacher ever require you to use the Internet or the computer for your homework or assignment?

(d) M-Thuto experience

20. Did you find any difficulties in seeing information on the mobile screen?
21. Did you find any difficulties in using your mobile phone in creating the audio clip?
22. Did you find any difficulties in uploading the clips (i.e. the Internet upload pace, experiencing difficulty with the system upload process)?
23. Did you find any difficulties in retrieving your audio clips for learning?
24. Which languages did you use to create your audio clips?
25. Which of the following sources did you use to look for learning content to help you to create the content for the clips? Please explain the process you followed when doing this? (newspapers, the mobile phone Internet, your science workbook, your class notes and any other sources)?
26. How often did you create the audio clips?
27. How often did you upload the audio clips?
28. How often did you revise using the audio clips?
29. Did you find the M-Thuto learning process effective in helping you to learn in your informal environment?
30. Would you like to have more learning material available on your mobile phone?
31. Would like to be able to communicate with your teacher on your mobile phone regarding concerns related to your school work?
32. Would having all you learning material available on your mobile phone motivate you to study anywhere outside the classroom? (please explain below)
33. If you had to change M-Thuto to make it more helpful towards your studies what would you add or change?

Teaches Interview questions

(a)Background questions

1. Teachers Name?
2. Name of School?
3. Home language?
4. Number of learner in his/her class?
5. What subjects do you teach?
6. Do you have a multilingual class if yes largely populated by which languages?
7. Do you ever feel that learners do not understand your language when you teach?
8. Do you ever try to elaborate using another language?
9. Does it assist the learner in anyway when you explain using more than one language?

(b) Technology questions

10. Do you use technology to support learners in their learning process?
11. Do you use any technology to support your teaching process?
12. Does the school have a computer laboratory in place?
13. For what purpose do they utilize this laboratory?
14. Do you ever give learners homework that requires them to use a computer?
15. Do you ever use technology in any way to conduct lessons?
16. If not why don't you use technology to support your teaching process?
17. Do you find M-Thuto helpful to you as a teacher, if yes how?
18. Do you think it would help to improve the learner's current performance?
19. Would you add any other feature to it that would make your work easier?

Appendix C – Interview guide for the studies presented in chapter 9

Teachers interview guide

Biographical information

- i. Do you have a mobile phone?**
- ii. Do you use it to receive email or use the Internet?**
- iii. Do you own one or more of the following?**

i.e. Laptop, Desktop Computer, Ipad/any mini laptops

- iv. Does the above mentioned device have an internet access?**

i.e. To check my email, To browse the Internet for learning material to present to learners in class, For personal use only

- v. Are you aware of any mobile phone learning systems or portals (for example Dr Maths?)**
- vi. Are you aware of any online based learning resources or websites?**
- vii. Do you ever encourage your learners to use computer or Internet to search for information?**
- viii. Which of these methods do learners in your class use to obtain learning material. Tick one box, you can tick more than one.**

i.e. Text books, Their class notes, Websites, The newspaper, Videos, Other please specify

- ix. Does your school have a computer or computers?**
- x. What does the school use the computers for?**
- xi. Which type of school do you teach in? (primary, high school)**
- xii. What is your first or home language (you can give more than one)?**

- xiii. **Which subjects do you teach?**
- xiv. **What are the teaching language policies in your school?**
- xv. **How many languages do you usually use in class when teaching?**
- xvi. **If the answer above is (b) when does the switch occur from English to the other language (example, when a learner does not understand what you said, when you are introducing a new topic or when the learner asks a question in the wrong way in class)?**
- xvii. **Which subjects do you find yourself switching often or on a regular base when you are teaching?**

Instructional design for code-switching in formal and informal environments

- i. **Which of the following reasons would define as important for switching between languages while teaching? Please provide reasons for your choice.(tick one box)**
 - (a) Reformulating or rephrasing concepts from language A to B to learners? ,
 - (b) Introducing new concepts to learners in language A and after a significant amount of content explaining the same concept in another language?
 - (c) Directly translating each content and concept from language A ?
- ii. **Given the above mentioned switching reasons how would you use the switch in formal content presentation for learners when you create learning content for formal classroom teaching?**
 - (a) after every word
 - (b) after each sentence
 - (c) After every paragraph

- iii. How and why would you also use switching to present informal learning content.
- iv. What are the type of activities that you use to facilitate the learning process in your class?
- v. Considering that learners have more access to mobile devices, do you think that mobile learning can be used to support the learning process?
- vi. If mobile devices were introduced as part of the learning process in schools would you use it in class as part of the teaching process? (please provide your answer and a short reason)
- vii. which of the three following methods would be best in supporting formal multilingual learning content switch: introducing content, reformulation and translating.

<i>Colum A: Introducing content of</i>	<i>Colum B: Reformulation</i>	<i>Colum C: Translation</i>								
<p>The capital of city of South Africa is Johannesburg with Cape Town providing the administrative home of parliament.</p> <p>Motsemoshate wa Afrika Borwa ke Gauteng. Mme Kapa Bophirima ke kwa mmusong was naga.</p>	<p>Todays Date <input type="text" value="6/8/2012"/></p> <p>a. Type in your name/Kwala lein la gago: <input type="text"/></p> <p>b. Please select your class name: grade 11 /</p> <p>Tlhopa leina la phapusi ya gago:</p> <p> <input type="radio"/> a <input type="radio"/> b <input type="radio"/> c <input type="radio"/> d <input type="radio"/> e </p> <p>c. The name of your school/ Leina la sekolo sa gago</p>	<table border="1"> <tr> <td>The</td> <td>sun</td> <td>is</td> <td>out</td> </tr> <tr> <td></td> <td>Letsatsi</td> <td>le</td> <td>tswile</td> </tr> </table>	The	sun	is	out		Letsatsi	le	tswile
The	sun	is	out							
	Letsatsi	le	tswile							

Scenario 1

You are teaching in classroom. A mobile learning system has been designed to support the learners providing them with class notes, class exercises and a quiz to enable them to learn. The content is presented using different languages in class.

Would you use this system to support the learners learning process in class

focusing on the language support and pedagogical support looking at figure 1?

Would you use the M-Thuto system to support informal learning looking at figure 2?

Formal learning support system:

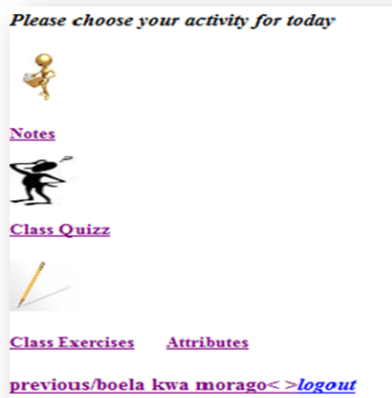


Figure 1. Interface for formal mobile learning system

Informal learning support system



Figure 2. Interface for informal mobile learning system

Students interview guide

SECTION A

Interview guide

Background and language information

1. Student name?
2. Student age?
3. Student gender?
4. Student country of origin?
5. Student home language?
6. How many languages can you thoroughly communicate in?
7. Which country did study for your high school certificate in?
8. Which language/s were you taught in during your high school education?
9. Explain the language policy for education in your country and if your school used the same policy as the national one.
10. Did you have a mobile phone in high school?
11. Did your school have supportive infrastructure and resources for studying (library, computers and access to internet, sufficient learning material)

SECTION B

Question- Please explain how the below electronic activities have been used to support your learning in formal environments, mention the activities that had already been used to support learning through mobile or electronic devices. Please also provide how language was used to support the electronic systems.

Activity	Software
Reading content	Mobile books
Assessment	Mobile quiz
Review / practice	Mobile worked class exercises

Table1. Supporting learning through mobile learning

Scenario – Introducing bilingual content to support mobile learning views

You are in a classroom where you are able to use a mobile learning system as part of the learning process in class. The system enables you to access learning content. Which of the below paragraphs would you prefer to use to learn a new concept in class (introduction of content), reaffirm what you have been taught (reinforcement), or need for translation of content (translation)?

Column A: English	Column B: Chinese	Column C: English and Chinese
The capital of China is Beijing. It is the second largest city after Shanghai. In China you can find great tourists attractions and a rich cultural history.	北京是中国的首都。它是第二大城市，仅次于上海。在中国，你可以发现非常棒的旅游景点以及丰富的历史文化。	The capital of China is Beijing. It is the second largest city after Shanghai. 北京是中国的首都。它是第二大城市，仅次于上海。 In China you can find great tourist's attractions and a rich cultural history. 在中国，你可以发现非常棒的旅游景点以及丰富的历史文化。

Table 2. Supporting code-switching through bilingual content

Questions – Current language and learning support in informal learning

How do you currently learn using any mobile or electronic device in informal environments?

How do you currently learn in informal environments using different languages?

Scenario example: You are relaxing at home or any other social area and are talking with your friends using a chatroom/ social site to revise some school work (Physical science, Mathematics etc) through your mobile phone. Which of languages would you use to learn and to communicate with your friend about learning content? Do you currently use any technology to help you learn in informal environments?

Scenario Introducing bilingual mobile learning activities to support informal learning.

You are presented with an informal mobile learning portal which allows you to access a learning system which supports your learning process outside of school or

in your informal environment. Which of these methods would you find effective in supporting your informal learning process?

<i>Activity</i>	<i>Software</i>
Keep track of class notes and help yourself to interpret and understand your content	Voice notes: Create notes through mobile device application and upload onto a dedicated mobile learning website
Discuss class notes and tasks with fellow students or with the teacher	Chatroom: Discuss critical learning factors in dedicated chatrooms which allow freedom of language.

Table 3. The informal mobile learning activities

Would you find the following portal effective in helping you learn in your informal environment?

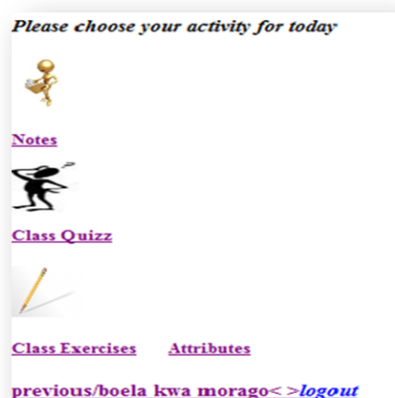


Figure 4. The formal learning activities